ANNALS OF SURGERY

VOL. 108 DECEMBER, 1938 No. 6

THE TREATMENT OF BRAIN ABSCESS *†

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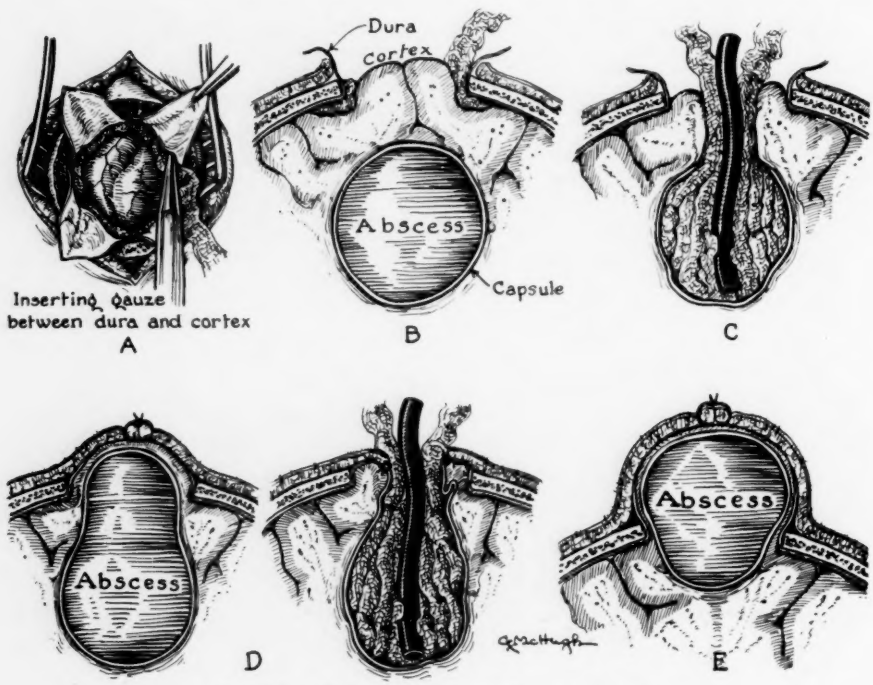
THE most appropriate method of dealing with abscesses of the brain is still the subject of discussion. Any method which has proved reasonably successful merits consideration. The present report is based upon a series of 17 consecutive cases in which the abscess has been dealt with surgically (Table I). Of the 17 cases, four were cerebellar and 13 were cerebral.† Of the former none died. Of the cerebral cases five died (29.4 per cent). In three of these five fatal cases the infection metastasized from the lung. In Case 2, there were multiple areas of infection throughout the body, in the chest, abdomen and pelvis, and a culture of the blood revealed *Staphylococcus aureus*, the organism found in the cerebral abscess. The patient improved greatly following drainage of a large abscess in the right parietal area, only to become unexpectedly stuporous on the eighth postoperative day and die within 24 hours. Knowing the tendency for abscesses which originate by metastasis from the lungs to be multiple, it was believed that death was probably the result of one or more other intracranial abscesses. Unfortunately, necropsy was refused. In Case 3, a child of 18 months, where the infection also arose from the lung, necropsy revealed a total of seven separate, intracerebral abscesses and a leptomeningitis. In Case 5, the child, age 3, was admitted in extremis, and died within less than 24 hours after admission and operation. Necropsy revealed an enormous abscess of the left parieto-occipital region which had ruptured into the lateral ventricle and produced a diffuse leptomeningitis, in all probability prior to the operation. It is difficult to see how any type of treatment could have benefited these three cases (unless in Case 5, a combination of drainage and the administration of sul-

* Presented before the Chicago Surgical Society, May 6, 1938. Submitted for publication April 21, 1938.

† Since preparing this paper an additional case has been treated and has recovered. The patient (F. S.) was a female, age 4, who had developed a right cerebellar abscess, apparently secondarily to a transitory right otitis media. Hemolytic Streptococci were recovered from the abscess. It was successfully treated with a single aspiration and the subsequent administration of sulphanilamide.

phanilamide which, however, did not exist at that time, 1932, might have proved effective). The other two fatal cases (Cases 9 and 13) presented entirely different conditions and will be considered in detail later.

Method Employed.—Since 1935, an endeavor has been made to treat all cases by the following method. Occasionally, as in Case 12, circumstances have precluded following this procedure completely or, as in Case 8, have made it unnecessary. No claim is made that the method is either new or original, only that it seems rational and, as will be seen, has been successful.



TWO-STAGE METHOD OF TREATING BRAIN ABSCESSES

FIG. 1.—First Stage: (A and B) An incision and small craniectomy are made over the abscess. A cruciate incision is made in the dura mater, and the subdural space about the opening is packed with gauze soaked in a weak solution of iodine.

Second Stage: (C) The usual finding at the second operation. The cerebral cortex has been sealed to the dura mater. The cortex overlying the abscess is removed and the abscess is evacuated and drained. (D) When the abscess has partially herniated through the craniectomy it can be marsupialized and drained. (E) Rarely, the abscess will be found to have herniated out of the skull. It can then be removed *in toto*.

First Stage.—The abscess having been localized, an incision is made over it. In the case of a cerebellar abscess of otogenic origin, the incision is a vertical one, made a short distance medial to the mastoid process and the wound of the mastoidectomy; with an otogenic abscess of the temporal lobe, the incision is just in front of the ear. The margins of the incision are separated by a self-retaining retractor. A trephine opening is made in the skull and enlarged with a rongeur to 3 or 4 cm. in diameter. A cruciate incision is made in the dura mater. The resultant triangular flaps of dura mater are

reflected exposing the tense and bulging cerebral cortex. A long strip of one-half inch selvedged gauze is soaked in one-fourth strength tincture of iodine and lightly dried with a gauze sponge. This gauze strip is then packed into the subdural space beneath the dura around the margins of the opening (Fig. 1 A and B). In doing so the pia-arachnoid membrane and cerebral cortex are moderately traumatized. If the patient's condition is satisfactory, nothing further is done and the wound is closed, bringing the end of the gauze strip out through the incision. If the patient is suffering from severely increased intracranial tension, a needle is inserted through the cortex into the abscess, after the subdural space has been walled off, and as much pus as will, allowed to escape. The needle is then withdrawn and the wound closed.

This method is designed to close off the meningeal spaces, subdural and subarachnoid, from the infectious material escaping from the abscess. It has long been recognized that the tendency for the brain to fall away from the dura as the abscess is evacuated opens these channels and is a great potential source of meningitis, usually a fatal complication. This method which deliberately promotes scar formation between the cerebral cortex, pia-arachnoid membrane and dura mater prevents this. It has been adopted from the thoracic surgeons, who utilize a similar procedure to obliterate the pleural space about the site of drainage of a lung abscess. Its success in the field of thoracic surgery is well known. Although it has been used by other surgeons, as noted by Davidoff,[3] the usefulness of the method is not commonly recognized. Some neurosurgeons attempt to wall off these spaces by cauterizing the dura mater and by suturing it to the pia-arachnoid membrane and then draining the abscess at the same operation (Adson and Craig,[1] and Davis[4]). Knowing the insecurity of sutures placed in the pia-arachnoid and the tenuous nature of adhesions produced by the dead coagulum resulting from the electric cautery, this method has been avoided in this clinic. The use of a two stage procedure, but without any mechanical or chemical stimulus to promote obliteration of these spaces, was advocated by Dowman, in 1923,[5] but not generally accepted.

In only one case have we had an opportunity to examine the meningocerebral scar produced by this method. As the case itself is unusual and interesting, it is presented in some detail.

Case 13.—Unit No. 191568: N. A. C., female, age 6, was referred by Dr. J. R. Doty of Gary, Indiana, with the diagnosis of a brain abscess. She was admitted to the University of Chicago Clinics January 24, 1938.

On November 1, 1937, the patient fell while playing, forcing a long dried weed up her right nostril. There was profuse bleeding but no other symptoms at the time. That night she vomited and complained of headache. Subsequently she had repeated episodes of headache and vomiting, which usually occurred in the early morning. The symptoms grew steadily more severe. The child lost weight, her appetite was poor and she became irritable. She was in bed during most of the month of January. There was no fever until January 16, 1938, when she developed a temperature of 103° F.

Some fever was present thereafter. On January 21, 1938, she developed a severe headache, vomiting and a stiff neck which persisted.

Physical Examination.—She was poorly nourished and dehydrated; and, although rather listless and irritable, was fairly cooperative, rational and well oriented. The superficial veins of the scalp in the right frontal region were dilated. There was marked stiffness of the neck. Kernig's sign was positive bilaterally. There was a severe bilateral papilledema with several hemorrhages. The visual fields were full to gross tests. There was a marked lower, left facial weakness. There was questionable slight weakness of the left arm (she was said to be left-handed) but no weakness in the lower extremities and no evidence of an aphasia. Tendon reflexes were active and equal on the two sides. There was a positive Babinski's sign on the left side. The

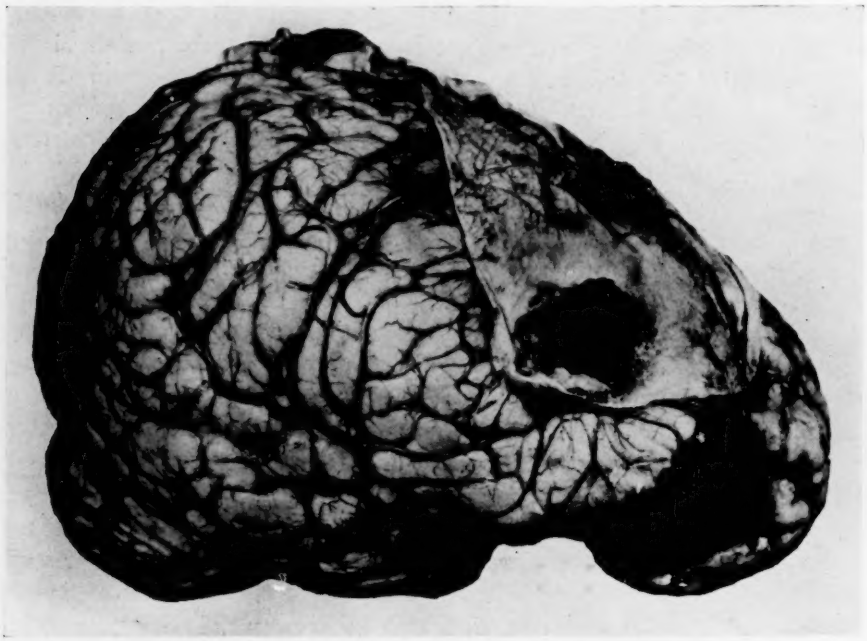


FIG. 2.—Case 13: Drainage of an abscess in the right frontal lobe. The dura mater is firmly adherent around the margins of the site of drainage. There has been no spread of infection to the neighboring meningeal spaces.

temperature was 37.5° C., pulse 60, and respirations 16. *Diagnosis:* Abscess of the right frontal lobe.

Operation.—First Stage. January 24, 1938: Under local anesthesia, an incision was made in the right frontal region parallel to and just back of the hair line. A trephine opening was enlarged to 3x4 cm. in diameter. The dura was incised and the cerebral cortex, which was under very great tension, herniated through the opening. The subdural space was packed. A brain puncture needle, inserted through the cortex, encountered the abscess at 2.5 cm. Forty-five cubic centimeters of pus were removed. The patient's pulse immediately rose from 60 to 90 per minute. Cultures of the abscess revealed hemolytic *Staphylococcus aureus* and pneumococcus, Type XXIV, for which there is no antiserum.

During the days which followed her pulse varied from 100 to 140, temperature remained about 38° C., respirations 20 to 26. Her condition was good. She ate and took fluids well.

On January 26, 1938, the subdural pack was removed. Two days later a needle was introduced through the incision into the abscess and 17 cc. of pus were removed. Cultures revealed that the pneumococci now predominated. On the evening of January 29, 1938, the temperature rose to 39° C.

Second Stage.—On January 30, 1938, the wound was reopened. There was considerable infection of the scalp, which was drained. The abscess had herniated through the defect in the bone for a distance of 1.5 cm. The abscess was incised and its contents evacuated. A piece of weed was recovered from within the abscess. The abscess occupied most of the right frontal lobe and measured 7 cm. in diameter. The capsule was sutured to the scalp (Fig. 1 D) and the cavity packed and drained.

Subsequently, she was much improved and the next day her temperature was normal (37° C.) for the first time since her admission. However, that evening at

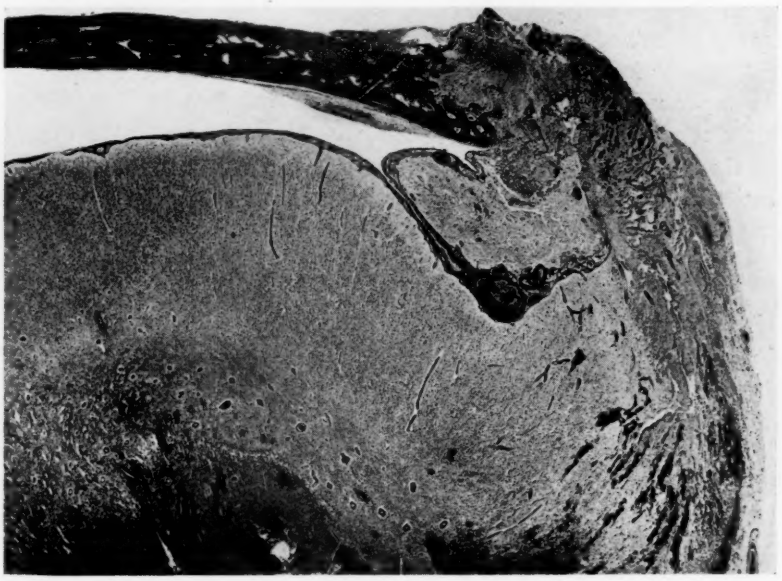


FIG. 3.—Case 13: Photomicrograph of the point of adhesion of the dura mater to the cerebral cortex. The dura mater is united to the cortex by a firm scar. The defect through which the abscess was drained is at the right. (Perdrau's method.)

6 P.M. her temperature suddenly rose to 40.7° C. The pulse increased from 100 to 164 and she became much more irritable. The wound was examined and seemed all right. There was no drainage of cerebrospinal fluid. A lumbar puncture was made. The fluid was opalescent and contained 4,060 cells which were almost all polymorphonuclear leukocytes. Cultures showed pneumococci. She was given sulphanilamide, fluids were forced and lumbar punctures were made three times daily. The spinal fluid gradually became less purulent but yellow in color, and after February 7, 1938, it was difficult to obtain more than a few cubic centimeters. A block had developed in the spinal subarachnoid space. Beginning February 3, 1938, the number of pneumococci in the spinal fluid began to diminish and by February 5, 1938, cultures of the fluid were sterile. However, her condition grew steadily worse and she died February 10, 1938, ten days after the onset of the pneumococcus meningitis.

Necropsy revealed the abscess in the right frontal lobe. The anteromedial part of the lobe was hemorrhagic and degenerated and very adherent to the cribriform plate on that side. When it was removed a portion of the weed was found projecting through

the cribriform plate from the nose into the cranial cavity. There was no evidence of meningitis over the convexity of the cerebral hemispheres or about the site of drainage of the abscess to the margins of which the dura was firmly adherent (Fig. 2). There was a thick layer of pus covering the hypothalamus, the undersurface of the pons and medulla oblongata. The infection had obviously spread backward from the region of the cribriform plates and not from the point of drainage of the abscess.

Figure 3 is a photomicrograph of the meningocerebral scar at the edge of the defect in the frontal lobe through which the abscess was drained.

Comment.—Although this case terminated unfortunately from a complication which could hardly have been foreseen or prevented, it demonstrates the adequacy of the method for the purpose for which it was designed. The dura was firmly sealed about the site of drainage and this sealing prevented the spread of infection at this point and effectively walled off the meningeal spaces from the infectious material (Figs. 2 and 3).

On one occasion (Case 12) the abscess was situated only 3 or 4 Mm. beneath the cortex. The subdural space was walled off as usual, but on puncturing the abscess with a needle it ruptured into the field, necessitating evacuation and drainage (as will be discussed below) at the initial operation. Although a most satisfactory result was obtained in this case, it is thought that the one stage procedure is too hazardous to warrant general use. In Case 8, the attack upon the intracerebral abscess was preceded by the removal of a focus of osteomyelitis in the skull and the evacuation of a large extradural abscess five months earlier. The two stage procedure was not necessary as this inflammatory process had walled off the subdural space.

If in the interim between the first and second stages signs of pressure develop, the abscess may be punctured and evacuated. In our experience, however, repeated evacuation through a needle will not suffice to cure an abscess which is not sterile. There may rarely occur cases in which repeated evacuation in this manner will not suffice to relieve tension and the delay necessitated by the two stage procedure may prove dangerous. It is believed that this may have been true in the following case.

Case 9.—Unit No. 154484: V. D., female, age 15, was taken ill, April 27, 1936, two months prior to admission, with a sore throat, chill and fever. Five days later pus began to discharge from both ears. Six days after this a right mastoidectomy was performed at another hospital and pus containing hemolytic Streptococci recovered. A week later the left mastoid was opened. The same organism was found. Eight days after this last procedure the patient had a chill, a temperature of 104° F., and Streptococci were recovered from the blood stream. A lumbar puncture performed three days later revealed a "normal" pressure, six cells, and Pandy's test was negative. The following day she developed pain in the left temple and about the left eye. The left mastoidectomy wound was reexplored but nothing unusual was found. The subsequent course was uneventful and she was discharged from the hospital three weeks later. She soon developed headache and began to vomit. These symptoms grew progressively more severe. A lumbar puncture demonstrated an increased pressure, 180 cells per cu. Mm., mostly lymphocytes, and Pandy's test gave a one plus reaction. She was then admitted to the University of Chicago Clinics, five days after discharge from the other

hospital and two months after the onset of the initial infection, complaining of headache.

Physical Examination.—The patient was mentally clear and alert. There was an early bilateral papilledema. The neck was slightly stiff. There were slight incoordination and weakness of the left arm. Blood pressure, 115/80. The examination was otherwise negative. The following day her headache was severe. Pulse had fallen to 52 per minute and she soon became comatose. A slight left facial weakness could be made out.

Operation.—Nine A.M., June 28, 1936: An incision and trephine opening were made in the right temporal region. The opening was enlarged with a rongeur to between 3 and 4 cm. in diameter. A cruciate incision was made in the dura and the brain herniated through the opening. A strip of gauze saturated with a weakened tincture of iodine was packed into the subdural space about the opening. A brain puncture needle was inserted and encountered the abscess at 2 cm. Ten cubic centimeters of pus flowed from the needle. Culture showed hemolytic Streptococcus. The wound was closed without further intervention. Subsequently, the patient became conscious and mentally alert. The pulse rose to 80. At 10 P.M. headache returned and the pulse fell to 68. At 5 A.M. the following morning the pulse fell to 50. Blood pressure, 130/80. The patient complained of considerable headache but was not stuporous. A needle was inserted but only 3 cc. of pus were obtained. Although her condition was much improved, it was decided to evacuate and drain the abscess later that morning. At 7:30 A.M. the pulse was 68; blood pressure, 130/70. At 8 A.M. the patient suddenly lost consciousness and respirations ceased. The pulse was 114; blood pressure, 194/150. She was immediately given artificial respiration. An unsuccessful attempt was made to puncture the abscess again. The patient was immediately reoperated upon. The opening in the temporal bone was enlarged. The abscess and a portion of the temporal lobe herniated into the field. They were removed. The pulse fell to 88 but spontaneous respiration was not resumed. She was placed in a respirator but died at 6:30 A.M. the following morning without regaining consciousness. Necropsy revealed that the abscess had been completely removed. There was a very severe cerebral edema and an acute purulent leptomeningitis.

Comment.—Of all our cases, this is the only one in which there is the slightest reason to believe that the delay, consequent to the two stage procedure, may have been responsible for the fatal outcome. Even here there is no assurance, in view of the fulminating course and the presence of an acute purulent meningitis at necropsy, that evacuation and drainage of the abscess at the first operation, less than 48 hours before death, would have produced a more fortunate result.

Usually, however, the patient's condition improves during the interval between the two stages. Forty-eight hours after the initial operation the gauze strip is removed permitting the tissues traumatized by mechanical and chemical means to come together and unite by scar formation. Approximately six days after the initial operation the second stage is undertaken.

Second Stage.—The procedure at the second operation naturally varies somewhat with what has taken place in the interval and with the findings at that time. In the great majority of cases the abscess will still be found beneath the cerebral cortex and will be treated by incision and drainage (Fig. 1 C). In a few instances the abscess will have migrated outward so that the dome protrudes through the defect in the skull (Fig. 1 D). These can

best be treated by marsupialization as advocated by Horrax.[6] Still more rarely, the abscess will have migrated through the defect in the skull (Fig. 1 E) and can be readily enucleated as recommended by Kahn.[7]

Drainage.—Usually at the second operation the cortex will be found herniated through the defect in the skull. The brain has become firmly sealed to the dura mater about the opening. The overlying cortex is removed either with suction or the high frequency electric cautery, exposing the surface of the abscess. The dome of the abscess is incised. The pus within is removed by suction, care being taken to avoid traumatizing or tearing the capsule. After insertion of ribbon retractors into the abscess, the interior can be investigated for evidence of neighboring communicating abscesses. A firm rubber drain, 1 cm. in diameter, is then inserted into the abscess cavity and held in place by suturing it to the skin. The remainder of the cavity is filled loosely with selvedged gauze which is also brought out and sutured to the skin edge. The skin is then closed about the drain. This method of dealing with the abscess is identical with that advocated by Adson and Craig.[1] The same method is equally adaptable to both cerebral and cerebellar abscesses, and there is little or no danger of contaminating the meningeal spaces, a very real danger in any one stage procedure. Within 24 to 48 hours removal of the gauze strips is begun, part being drawn out and removed each day. After removal of the gauze the rubber drain is released from its anchorage to the skin. It will be forced out gradually as the capsule collapses. The drain is cut off each day as it is extruded. The time and rate of removal of the rubber drain will depend upon the rate of healing of the abscess as determined by the amount of drainage and rate of extrusion of the tube. The following case reports will exemplify the method in a cerebral and in a cerebellar abscess.

Case 11.—Unit No. 168171: I. G., female, age 7, was referred to us by the Children's Memorial Hospital, Chicago, where she had been admitted January 7, 1937. Two weeks previously she had developed an upper respiratory infection which was complicated by an infection in the right ear. On January 9, 1937, a simple right mastoidectomy was performed but no pus was found and she did not improve. Six days later the wound was reexplored and pus was obtained from cells in the zygomatic region. Two days later, January 17, 1937, she developed a severe headache. Examination revealed a bilaterally positive Kernig's sign, a left Babinski's sign and left ankle clonus. That day, the wound was again explored and an extradural abscess found in the region of the squama of the temporal bone and drained. She improved until eight days later, when she developed a severe frontal headache, a left facial weakness and Babinski's sign was again present on the left. The headache persisted. She became stuporous and the pulse dropped from 115 to 60. On January 27, 1937, a lumbar puncture was made. The pressure was 150 Mm. of fluid, the test for globulin was positive; there were 15 white blood cells, nine of which were polymorphonuclear leukocytes. Cultures of the fluid were negative. The patient was first seen by me January 29, 1937, 12 days after the onset of the first intracranial symptoms.

Physical Examination.—The patient was comatose. There was no response except to painful stimuli. There was a marked left facial weakness. The right pupil was

twice the size of the left. The tendon reflexes were active and equal. Babinski's sign was positive on the left. The optic disks were flat and normal. *Diagnosis:* Abscess of the right temporal lobe and, although it was thought probably to be a futile procedure, an operation was undertaken.

Operation.—January 29, 1937: The first stage was carried out as outlined above. The subdural space was packed off. A needle was inserted. It encountered the abscess at 2 cm., and 45 cc. of dirty, reddish purulent material flowed out. Culture showed a hemolytic Streptococcus. The wound was closed.

At the beginning of the operation she was comatose, pulse, 60. At the close she was fully conscious and the pulse was 80. Two days later, January 31, 1937, the gauze was withdrawn from the subdural space. Her temperature, pulse and respirations were normal and remained so thereafter. Examination revealed only a left homonymous, upper quadrantic defect in the visual fields and a slight left facial weakness. On February 6, 1937, she complained of a slight frontal headache and 28 cc. of pus were aspirated. The following day 20 cc. more were removed.

Second Stage.—February 8, 1937, ten days after the first stage: The previous incision was reopened. The abscess was now only 1 cm. beneath the surface. The abscess was treated exactly as described above. For the next three days the drainage was profuse. By February 16, 1937, eight days after drainage of the abscess, the gauze pack had been removed and the amount of purulent drainage was considerably reduced. Four days later the suture restraining the rubber tube was cut and the tube was gradually extruded, and was entirely removed March 13, 1937, 33 days after drainage of the abscess. The wound was healed by March 24, 1937, and she was discharged from the hospital perfectly well two days later, exactly eight weeks after admission. She was last seen April 25, 1938, at which time she was perfectly well. Neurologic examination was entirely negative and the visual fields were full.

Comment.—In addition to strengthening our faith in this method of treatment, this case has made us wary of despairing of any case of brain abscess until all possible therapeutic measures have been exhausted.

Exactly the same procedure is equally suitable for the treatment of abscesses of the cerebellum as illustrated by the following case.

Case 15.—Unit No. 50693: D. Y., male, age 7, was referred by the Children's Memorial Hospital, Chicago. In the autumn of 1934, he developed pneumonia which was followed by a left otitis media. In February, 1935, an attack of scarlet fever resulted in a reactivation of the otitis media. On March 27, 1935, he developed a frontal headache, continuous vomiting, and as a result rapidly lost weight. He was admitted to the Children's Memorial Hospital two days later. At that time he was alternately irritable and stuporous. There was a slight rigidity of the neck. A lumbar puncture was made. The pressure was "normal." There were 480 white blood cells, 60 per cent lymphocytes. Cultures were negative. There were 56 mg. of glucose per 100 cc. He developed a right sixth and seventh cranial nerve weakness, a mild left hemiparesis and became stuporous. Two days later a left external rectus weakness developed. Subsequently his condition improved. Roentgenograms made on April 24, 1935, revealed a slight separation of the cranial sutures. On May 10, 1935, an early papilledema was observed. Eight days later he was admitted to the University of Chicago Clinics.

Physical Examination.—There was no spontaneous voluntary movement of the left arm or leg but they were not paralyzed. There was gross incoordination of the left arm and leg with marked flaccidity of those extremities. The gait could not be tested. The optic disks were choked. Ocular movements were full but there was a slow, coarse nystagmus on looking to the left. The tendon reflexes were uniformly diminished.

Babinski's sign was not present. The neck was moderately stiff. Kernig's sign was not present. *Diagnosis:* Abscess of the left cerebellar hemisphere.

First Stage.—May 23, 1935: The usual incision and small craniectomy were made over the left cerebellar hemisphere. The subdural space was packed about the opening and the wound closed. Two days later he was in excellent condition. The subdural pack was removed.

Second Stage.—May 28, 1935: The former incision was reopened. The abscess was found 0.5 cm. below the surface. It was opened, evacuated and a firm rubber drain inserted as described above. Smears of the pus revealed Streptococci.

Following the operation there was moderate drainage. On June 2, 1935, the suture holding the drain in place was cut and the drain was slowly extruded. It was completely removed June 12, 1935. By June 18, 1935, the wound was healed and the patient was able to walk unaided. He was discharged June 30, 1935, 38 days after the first operation.

When last seen, September 15, 1937, two years and four months after the operation, the boy was perfectly well. There was no evidence of any cerebellar disturbance.

Marsupialization.—Occasionally when the wound is reopened at the second operation, the dome of the abscess will be found to have herniated through the defect in the bone (Fig. 1 D). In such cases, the abscess can be opened, evacuated and the capsule sutured to the subcutaneous tissue or scalp, thus marsupializing it as recommended by Horrax.[6] The abscess is then drained and packed as previously described. In the following case this method was used.

Case 17.—Unit No. 169671: D. H., male, age 14, was referred by Dr. Raymond Brown of Joliet, Illinois. In November, 1936, he developed an upper respiratory infection. The following month a right otitis media appeared. One week later, December 26, 1936, he developed a severe headache, complained of dizziness and then gradually grew worse. On January 8, 1937, a right mastoidectomy was performed. Although his general condition improved, it was soon noted that the right arm and leg were unsteady. On February 12, 1937, he developed a very severe headache and the following day projectile vomiting appeared. He was admitted to the University of Chicago Clinics February 19, 1937. He was an intelligent cooperative patient. He was and for years had been excessively obese. There was a bilateral papilledema of two diopters. The visual fields were full. Upward conjugate deviation of the eyes was poorly done. There was a nystagmus on looking to either side, more marked to the right, and on looking upward. The right upper and lower extremities were hypotonic and their movements were very ataxic. There was marked dysdiadokokinesis on the right side. He was unable to stand with his feet together and swayed when he stood with his feet wide apart. He staggered when he walked, falling mostly to the *left*. The neck was stiff. The tendon reflexes were more active on the right. There was a sustained ankle clonus on the right, unsustained on the left side. Babinski's sign was present on the right. The temperature and respirations were normal; pulse, 100. *Diagnosis:* Right-sided cerebellar abscess.

Operation.—First Stage. February 20, 1937: A vertical incision and an opening in the occipital bone were made over the right cerebellar hemisphere. The subdural space was packed. A needle was inserted which encountered the abscess at 1 cm.; 45 cc. of greenish white pus flowed out. The organism proved to be a pneumococcus, Type II.

Subsequently his condition was much improved; the ataxia practically disappeared.

The subdural pack was removed in 48 hours, and six days after the first operation the second stage was undertaken.

Second Stage.—February 26, 1937: The old incision was reopened. The dome of the abscess had herniated through the opening in the bone. It was incised and the capsule sutured to the subcutaneous tissue. The pus within the abscess was evacuated and a firm rubber tube drain inserted.

Two days later, he developed a diplopia and a weakness of the right external rectus muscle which persisted until his discharge from the hospital. The wound did not drain well. On March 7, 1937, nine days after drainage was instituted, the wound became tense and two days later began discharging cerebrospinal fluid. The patient was placed flat in bed and fluids were forced. The drainage of cerebrospinal fluid was profuse. On March 11, 1937, the signs of right cerebellar involvement returned but began to subside about six days later. By March 24, 1937, the amount of cerebrospinal fluid drainage had become reduced and four days later it ceased, but herniation of the wound appeared and grew progressively more marked. On April 3, 1937, the wound was reopened. No abscess was found and the cerebellar hernia was amputated. The wound was drained and subsequently discharged cerebrospinal fluid which on culture was found to contain hemolytic *Staphylococcus aureus*. On April 19, 1937, the optic disks were flat. The patient had no headache. There was a marked nystagmus on looking to the right and severe right-sided signs of cerebellar deficit. By April 27, 1937, all drainage of cerebrospinal fluid had ceased and the patient was up in a chair. A slight purulent discharge persisted. On May 13, 1937, a small bony sequestrum was removed. By June 9, 1937, the wound was completely healed and the patient was discharged. He was able to walk, but rather severe cerebellar signs still persisted. When seen November 8, 1937, he had gained 15½ pounds in weight since leaving the hospital and weighed 221½ pounds. His station and gait were good. He could stand with his feet together without swaying. There was still considerable dysdiadokokinesis of the right hand, and his writing, though legible, was poor. The wound was well healed, bulging slightly. The optic disks were flat. He was placed on a limited diet and within a month lost 23½ pounds. He is feeling well and the remaining cerebellar signs are rapidly diminishing.

Comment.—In addition to illustrating the utilization of the marsupialization technic, which is limited in its usefulness to a very small group of cases, this case illustrates the method of dealing with a leak of cerebrospinal fluid employed in this clinic. This is a point which will be dealt with in more detail later.

Enucleation.—Like many other neurosurgeons, we have had the experience of enucleating an encapsulated abscess under the mistaken impression that we were dealing with a tumor. Case 1 was an instance in point. It needs no further discussion. Vincent's[8] technic of repeated aspiration of an abscess until it develops a thick capsule and then deliberately reflecting an osteoplastic flap and enucleating the abscess as one would a tumor appeals to us as a rational method of treatment. It is most suitable for abscesses in the frontal lobes. We have had no opportunity to use exactly this technic since we learned of it but the following case is not dissimilar.

Case 10.—Unit No. 156653: M. G., female, age 3, was referred by Dr. Frank Greer, Chicago. About July 10, 1936, she developed a stye on the left eyelid. On July 12, 1936, she fell out of bed striking the region of the left eye. The following day she developed a fever of 102° F. which persisted for several days. On July 16,

1936, a tender swelling appeared in the left temple and the eye was swollen shut. On July 20, 1936, the temporal swelling was incised and pus and blood evacuated. The edema of the eyelids subsided and she was found to have a strabismus. The temporal abscess soon reformed and she was admitted to the University of Chicago Clinics July 29, 1936.

Physical Examination revealed no neurologic or other abnormalities other than the tender fluctuant swelling in the left temporal region. Roentgenograms of the skull were considered normal except for a questionable erosion of the lateral margin of the left orbit. The temporal region was incised and a large abscess found beneath the temporal muscle, which was drained. Cultures of the pus revealed hemolytic *Staphylococcus aureus.* The wound soon healed and the patient was discharged August 26, 1936. On September 3, 1936, she developed nausea and vomiting and was readmitted to the Clinics. Examination revealed a small swelling in the left frontal region just at the hairline. Neurologic and ophthalmoscopic examinations revealed no abnormalities. Roentgenograms of the skull showed a small area of osteomyelitis present beneath the swelling. On reviewing the roentgenograms, made during her previous hospitalization, it was obvious that this area of osteomyelitis, though much smaller, had been present at that time and had been overlooked. The area of osteomyelitis was extirpated and the wound packed. There was no extradural abscess and the dura mater was under no unusual tension. The same organism was cultured. Seven days later, September 15, 1936, she complained of headache and vomited. Examination revealed early papilledema, a diminution in voluntary use of the left arm and leg, a left facial weakness, diminution of the tendon reflexes on the left side with a left Babinski sign. Sensation was intact. *Diagnosis:* Brain abscess in the right precentral region (*i.e.*, contralateral to the original infection).

Operation.—First Stage. September 16, 1936: The right precentral region was exposed, the subdural space packed. A brain puncture needle was inserted and an abscess encountered at 6 cm. Thirty cubic centimeters of pus were evacuated. Culture revealed hemolytic *Staphylococcus aureus.*

The following day the patient was much better but symptoms of refilling of the abscess soon appeared. Four days after the first stage operation and evacuation of the abscess, a needle was inserted through the wound into the abscess. Pus flowed out, only to be followed shortly by cerebrospinal fluid. This we interpreted as due to rupture of the lateral ventricle into the abscess. At this depth (6 cm.) the ventricle presumably lay immediately beneath the abscess. The original needle was replaced by a slightly shorter needle of the T-shaped type designed by Frazier. Within two days the drainage of cerebrospinal fluid ceased and the needle was withdrawn. Her condition continued to improve and it was hoped that repeated aspiration of this deep-seated abscess would suffice, but not so. On October 29, 1936, about one and one-half months after the original aspiration, the wound began to herniate. The abscess was punctured and evacuated repeatedly. The abscess was encountered more and more superficially. On November 17, 1936, the wound was reopened and the opening in the bone enlarged. The subdural space was, therefore, again packed off. A needle encountered the abscess at 3 cm. and 25 cc. of pus were removed.

Drainage.—Seven days later, November 24, 1936, the wound was again reopened. The brain tissue overlying the abscess was removed with the Bovie high frequency current. The abscess was opened and evacuated, and beneath it was found a second abscess which communicated with the uppermost by a narrow neck. It, too, was opened, a firm rubber drain inserted, and the cavities packed as previously described.

The packing was removed by December 2, 1936, and the rubber tube by December 21, 1936. The wound soon healed and was depressed. But by January 17, 1937, it was bulging again. Two days later 25 cc. of pus were aspirated. On January 22, 1937, 15 cc.

were removed. January 23, 1937, the wound was again opened. The abscesses were found, evacuated and drained. On February 10, 1937, the drain was finally removed. The wound soon healed and the patient was discharged from the hospital February 14, 1937.

On February 25, 1937, she fell from a chair and struck her head. The next day she developed a headache, vomited and had a temperature of 101.2° F. She was readmitted on February 27, 1937. The wound was bulging and discharging some pus. She had a left hemiparesis which has been present almost from the outset. Thirty cubic centimeters of pus were aspirated but the wound soon filled out again.

Enucleation.—March 6, 1937: An osteoplastic flap was reflected. The abscess was carefully dissected free from the surrounding brain but in the inferior part the wall was very thin and ruptured. The ventricle was opened. The wound was drained through the center of the scalp flap, the bone being discarded. Cultures revealed the same organism, namely, hemolytic *Staphylococcus aureus.*

The patient was kept flat in bed. Fluids were forced. A profuse drainage of cerebrospinal fluid continued for two weeks. By April 12, 1937, the wound was entirely healed and has remained so. The child has a severe left hemiparesis but is otherwise well. There have been no further symptoms of recurrence of the abscess.

Comment.—In this case both repeated aspiration and drainage failed to cure the abscess. Enucleation was finally undertaken more or less in despair. The results were sudden and excellent. It is unfortunate that the right central region and internal capsule were involved but no method of treatment could have altered this or the appearance of the hemiparesis. This case again illustrates the development and treatment of a leak of cerebrospinal fluid.

Recently, Kahn[7] has advocated a two stage procedure, at the second stage of which the tumor is enucleated. Kahn's first stage is similar to that described in this paper except that Kahn does not advocate puncturing the abscess—a procedure which, in this clinic, has been found at times to be of great value in reducing the intracranial tension and tiding the patient over to the second stage. At the second stage Kahn has occasionally found the abscess extruded out of the skull. When this occurs, as illustrated by Case 8, abstracted below, the abscess is readily removed (Fig. 1 E). Usually, however, although the abscess will be found to have migrated nearer the surface, it will still be beneath the level of the skull. In such instances Kahn removes the overlying brain tissue by suction, incises and evacuates the abscess and then removes the capsule by dissecting it free from the surrounding brain tissue. It is obvious that removal of an extruded brain abscess *in toto*, when possible, is a highly satisfactory method of treatment. Dissecting the capsule free from the surrounding traumatized and edematous brain tissue after the field has been contaminated by incising and evacuating the abscess is not, however, as free from danger and not a procedure that we have felt justified in employing. The following case illustrates the possibility of removing an abscess after it has been extruded from the skull although the course followed is not identical with that outlined by Kahn.

Case 8.—Unit No. 40528: C. B., male, age 19, had been treated in this clinic, where he had been referred by Stanley H. Skrentney, Hammond, Indiana, in June, 1931, because of multiple areas of osteomyelitis. He had suffered from convulsive seizures for years.

About July 15, 1935, he developed an abscess beneath the scalp in the left parietal region. He was admitted to the hospital October 2, 1935, because of this swelling, difficulty in talking and numbness of the right hand. Roentgenograms, revealed an area of osteomyelitis in the left parietal bone.

Physical Examination.—The patient had a definite aphasia, the optic disks were not quite clear but were not choked. Sensation was slightly reduced on the right side. The knee and ankle jerks were more active on the right. Babinski's sign was present bilaterally. There was a sustained ankle clonus on the right, unsustained on the left.

Operation.—October 3, 1935: The subaponeurotic abscess was evacuated; the area of osteomyelitis measuring 5x6 cm. was removed and an extradural abscess 1.5 cm. deep at its thickest point evacuated and drained. The infecting organism was *Staphylococcus aureus.*

He rapidly improved thereafter and was discharged October 19, 1935, returning to the outpatient department for dressings. On November 6, 1935, he had a jacksonian convulsive attack involving the right hand. The wound was healed by December 27, 1935. He was quite well until the latter part of January, 1936, when he began to suffer from headaches. On February 26, 1936, the wound was bulging and tense and there was bilateral papilledema of two diopters. He was again admitted to the hospital. There was a slight right facial weakness, the right arm was weak and its movement slow and poorly coordinated. Sensation was slightly reduced on the right. Reflexes in the right lower extremity were increased and Babinski's sign was present.

Operation.—February 28, 1936: The old incision was reopened. There was no extradural collection of pus. The dura mater was incised. The brain was brown and gelatinous and adherent to the dura. A needle encountered an abscess a few millimeters below the surface. Subsequent events showed that the abscess should have been enucleated, a procedure which would have been relatively simple. However, because of its location it was incised, evacuated and drained in the hope of causing less neurologic disturbance. There was only moderate drainage. On March 6, 1936, the wound began to bulge. By March 8, 1936, his speech had become worse.

Enucleation.—On March 11, 1936, the herniation having become more marked, the wound was reopened. The abcess had herniated out of the skull and was readily removed.

By March 24, 1936, the brain was again herniating, and the patient had become completely aphasic. On April 1, 1936, he had a large infected fungus. Three days later this was amputated with the Bovie electrosurgical unit. A fistula draining cerebrospinal fluid resulted. The patient was placed flat in bed and fluids were forced. The drainage of cerebrospinal fluid continued until April 28, 1936. The wound was healed by June 7, 1936. He has continued well except for a severe right hemiparesis and a partial aphasia.

Comment.—The unfortunate permanent result obtained in this case, of a hemiplegia and a partial aphasia, was because of the location of the abscess and is in no way attributable to the method of treatment. Undoubtedly the whole course could have been materially shortened by enucleating the abscess when it was first exposed. That was accomplished in Case 4, where a small abscess, about 3 cm. in diameter, was found just beneath the dura and an area of osteomyelitis in the temporal bone.

Repeated Aspiration.—Dandy[2] has recommended that abscess of the brain be treated simply by aspiration. He states that one aspiration may suffice or that occasionally one, two or three additional tappings may be necessary. Our own experience with this method has not impressed us with its efficacy. In one instance previously cited, Case 10, many more aspirations than four

were undertaken, without more than temporary relief, and much more radical treatment was necessary to obtain a cure. In only one instance was simple aspiration effective.

Case 6.—Unit No. 90999: J. A. M., male, age 26, was struck over the head with a lead pipe September 27, 1933. He sustained a compound, comminuted, depressed fracture in the upper right central region. He was admitted to the University of Chicago Clinics about 12 hours after the injury. His left arm was completely paralyzed; the arm was flaccid. There was a left lower facial weakness. The tendon reflexes were diminished in the left arm. He was operated upon immediately. The fragments of bone were removed. One had been driven through the dura. The wound was thoroughly débrided and closed. On October 2, 1933, five days later, purulent drainage (hemolytic Streptococcus) appeared. The strength of the arm was improving. The following day the left leg became weak and Babinski's sign was present. On October 10, 1933, a localized subaponeurotic abscess was drained. On October 21, 1933, he had some headache and a moderately stiff neck. The scalp wound was opened more extensively and in doing so the dura was unintentionally nicked. The cortex protruded through this opening. A needle was inserted and at 2 cm. encountered an abscess from which several drops of thick pus were obtained. Culture showed hemolytic Streptococcus. Only the scalp wound was drained. He soon began to recover and was discharged on November 24, 1933. He has an almost completely paralyzed left arm and walks with a hemiplegic gait, but there have been no signs of progression of his abscess and he has been seen frequently during the years since his accident.

Comment.—It seems very questionable whether the aspiration of a few drops of pus from this small abscess played any part in its cure but there was no other specific treatment to which credit could be given.

Leakage of Cerebrospinal Fluid.—It has long been felt, in this clinic, that the leakage of cerebrospinal fluid from a wound engenders an unreasonable fear in many surgeons and that it is, therefore, usually treated in a thoroughly illogical manner. This seems particularly true of leakage occurring in association with the drainage of a brain abscess. Obviously, there is but one place for such fluid, infected by reason of its contact with an infected field, and that is outside the skull. To attempt to prevent its escape by closing the opening with devitalized bits of muscle or other means, or by performing lumbar punctures and drawing the contaminated fluid back into the general cerebrospinal fluid circulation, is without merit and only to be condemned as extremely hazardous. Our procedure is to encourage as free a flow of the fluid as possible. To this end, we place the patient flat in bed or even lower the head below the level of the rest of the body and force the patient to take as much fluid as possible. The drainage is allowed to cease and the opening to close spontaneously. This procedure, employed in the six cases which developed such leaks (Nos. 8, 10, 12, 14, 16 and 17), has been uniformly successful.

When to Operate.—The neurosurgeon has always been greatly concerned about when to operate upon an abscess of the brain. It is generally agreed that operations upon well encapsulated abscesses will be more successful, and that encapsulation requires about four to six weeks. In many instances, however, the patient's condition will not permit of such prolonged delay. An

TABLE

SYNOPSIS OF STATISTICAL DATA RELEVANT

Case No.	Name	Unit No.	Sex	Age	Date of Onset of Original Infection	Date of Onset of Abscess	Date of First Operation	Date of Discharge	Origin
									CERE-
1	W. J. G.	11789	M.	15 yrs.	11–17–28	12–18–28	5–14–29	6– 7–29	Right ear
2	L. K.	19702	F.	37 yrs.	10–15–29	11–14–29 (?)	2–13–30	2–22–30 Died	Multiple infections; + bloodculture
3	J. P.	35919	M.	18 mos.	8–22–30	11– 5–30 (?)	11–25–30	12– 5–30 Died	Empyema
4	W. R.	51849	M.	61 yrs.	4– ?–31	6– ?–31	12–28–31	3– 8–32	Osteomyelitis right fibula and skull
5	R. M. K.	64749	F.	3 yrs.	3– ?–31	7–10–32 (?)	7–28–32	7–29–32 Died	Empyema; bronchiectasis
6	J. A. M.	90999	M.	26 yrs.	9–27–33	(?)	10–21–33	11–24–33	Compound skull fracture
7	M. O.	106530	F.	7 yrs.	?	3–14–34	6–28–34	8– 4–34	?
8	C. B.	40528	M.	19 yrs.	7–15–35	?	2–28–36	6– 7–36	Osteomyelitis of skull
9	V. D.	154484	F.	15 yrs.	4–27–36	?	6–28–36	6–30–36 Died	Right ear
10	M. G.	156653	F.	3 yrs.	7–10–36	9– 3–36	9–16–36	4–12–37	Osteomyelitis of skull
11	I. G.	168171	F.	7 yrs.	12–25–36	1–17–37	1–29–37	3–26–37	Right ear
12	T. S.	178470	M.	10 yrs.	6–20–37	6–22–37	8–10–37	9–16–37	Right ear
13	N. A. C.	191568	F.	6 yrs.	11– 1–37	11– 1–37	1–24–38	2–10–38 Died	Ran stick up nose into brain
									CERE-
14	B. S.	50693	F.	11 mos.	1–26–31	3– 1–31	12– 2–31	2– 3–32	Pneumonia
15	D. Y.	128349	M.	7 yrs.	Autumn 1934	3–27–35	5–23–35	6–30–35	Left ear
16	G. C.	153198	F.	4 yrs.	5– ?–35	5–31–36	6–12–36	4– 5–37	Bilateral mastoiditis
17	D. H.	169671	M.	14 yrs.	12–19–36	12–26–36	2–20–37	6– 9–37	Right ear

I

TO 17 CASES OF ABSCESS OF THE BRAIN

Organism	Location	Treatment	Cerebrospinal Fluid Leak	Result	Remarks
BRAL					
?	Right temporal	1 stage; enucleation	o	Recovered	Blind before operation
Staph. aureus	Right parietal	1 stage; drainage	o	Died	No necropsy
Chest: Strep. Brain abscess: No growth	Right parietal	1 stage; drainage	o	Died	Necropsy: Multiple (7) abscesses right cerebral hemisphere; meningitis
Staph. aureus	Right temporal	1 stage; enucleation	o	Recovered	Died several months later; cerebrovascular accident (?)
Strep.	Left occipitoparietal	1 stage; drainage	o	Died	Ruptured into ventricle before operation
Strep. hemol.	Right central	Single aspiration	o	Recovered	Left hemiparesis; convulsions
Strep. hemol.	Right central	1 stage; drainage	o	Recovered	Left hemiparesis; jacksonian convulsions
Staph. aureus	Left central	1 stage; drainage, later enucleation	+	Recovered	Right hemiparesis; partial aphasia; convulsions years before abscess
Strep. hemol.	Right temporal	2 stage; drainage	o	Died	Necropsy: Abscess removed at second operation; severe edema; meningitis
Staph. aureus	Right central	2 stage; repeated aspiration; drainage; enucleation	+	Recovered	Left hemiparesis
Strep. hemol.	Right temporal	2 stage; drainage	o	Recovered	No sequelae
Strep. hemol.	Right temporal	1 stage; drainage	+	Recovered	No sequelae
Staph. aureus, pneumococcus Type XXIV	Right frontal	2 stage; drainage	o	Died	Necropsy: Stick found protruding through cribriform plate. Basilar meningitis spread from this point.
BELLAR					
Sterile	Vermis and right hemisphere	1 stage; drainage	+	Recovered	Impaired vision; retarded growth; obese
Smear: Strep., culture negative	Left hemisphere	2 stage; drainage	o	Recovered	No sequelae
Strep. hemol.	Right hemisphere	2 stage; drainage	+	Recovered	Slight cerebellar deficit
Pneumococcus Type II	Right hemisphere	2 stage; drainage	+	Recovered	Slight cerebellar deficit

operation postponed too long may result, if not in death, in blindness (*e.g.*, Cases 1 and 14). As near as it has been possible to estimate, the period from the onset of the cerebral infection until operation has varied in our cases from 12 days to nine months. In the instance of shortest duration, Case 11, previously cited, the short duration of the abscess infected with hemolytic Streptococci cannot be said to have in any way interfered with obtaining an excellent result as this is one of the most striking cases in this series. This patient, whose original infection (otitis media) had occurred only one month previously, and whose first symptom of invasion of the nervous system appeared only 12 days before admission, was brought into the hospital comatose. She was operated upon by the two stage procedure herein outlined, and was discharged from the hospital completely recovered less than two months later.

The majority of abscesses had best be attacked as soon as the diagnosis has been made with reasonable certainty. In a few cases, where conditions will permit, a short delay, with the patient under close observation may be desirable in order to afford more time to allow of better encapsulation. Unfortunately cases where this is possible are all too rare. Nor is such delay entirely without danger. Rupture of the abscess into the ventricle (Case 5), the development of a meningitis, or of a severe and fatal cerebral edema (Case 9), are possibilities.

SUMMARY

Seventeen consecutive cases of abscess of the brain treated by surgical means are reported. Twelve of these (70.6 per cent) recovered. Five (29.4 per cent) died. In three of these fatal cases the abscess arose from the lung. In one case, multiple abscesses of the brain were found at necropsy; in another, multiple areas of infection, including the blood stream, were present throughout the body and multiple brain abscesses were suspected; in a third, the abscess had ruptured into the ventricle prior to operation. In the fourth case, the abscess arose from the ear and was located in the temporal lobe; it was a particularly fulminating case and the patient died soon after the first stage. Necropsy revealed that the abscess had been removed at an emergency second operation and that a leptomeningitis was present. In the fifth case, an abscess of the right frontal lobe developed as the result of the penetration of a stick through the cribriform plate into the brain. After drainage of the abscess and relief of the pressure, a basilar meningitis spread backward from the region of the cribriform plate, causing death.

A method of surgical procedure is outlined. It is designed to prevent meningitis by contamination of the meningeal spaces. It consists of two stages. At the first stage, a small craniectomy is made, the subdural space is packed off with gauze soaked in a weak solution of iodine, and the abscess may or may not be punctured and partially evacuated. The gauze is removed 48 hours later. At the second stage, some six days after the first,

the abscess will be found to have migrated nearer the surface. The overlying brain tissue is removed and the abscess is evacuated and drained.

In addition, the questions of enucleation of the abscess, of treatment by repeated aspiration, the problems of dealing with leaks of cerebrospinal fluid, and of when to operate are discussed.

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CARCINOMATOUS METASTASES TO THE BRAIN

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THE treatment of carcinomatous metastases to the brain is a subject which is unlikely to arouse much general interest because of the hopeless outlook from a curative standpoint. However, on the same basis, the ultimate prognosis is almost equally discouraging in infiltrative gliomata (glioblastoma multiforme). In fact, all types of palliative surgery for malignancy fall into this category, in which an eventual mortality is inevitable.

With the realization that curative therapy is impossible, it becomes necessary to seek other criteria upon which to base the advisability or inadvisability of surgical intervention. Obviously, the simplicity or multiplicity of the intracranial lesion is of primary importance. The present report is based entirely upon cases in which the metastasis appeared to be solitary. As in other forms of palliative surgery, three other factors must be considered: (1) The relief of symptoms; (2) duration of life; and (3) the operative mortality. The present cases are analyzed in regard to these three factors.

Grant,[1] in 1926, compared the results in 25 cases, in whom some form of intracranial operation was performed, with those in 22 cases who were not operated upon. He stated: "The average length of life from time of admission to this hospital to death in both verified and unverified cases, whether operated or non-operated, whether radical extirpation or palliative decompression was performed, was less than four months." There is no doubt that these discouraging results have strongly tempered the opinion of the profession regarding surgical intervention in cases of malignant intracranial metastases. However, one conclusion of Grant's is often overlooked. After stating that surgery is unable to prolong the life of these patients, he added: "But surgical intervention for the relief of intracranial pressure is frequently indicated and may go far toward relieving suffering in the last few months of life."

Shelden,[2] in 1926, reviewed 40 cases of secondary tumors of the brain, from the aspect of diagnosis. Although his paper was not primarily concerned with surgical indications, he distinctly intimated that surgical intervention was not advisable. This passive attitude toward the problem was challenged by Oldberg,[3] in 1933. He reported three cases of metastatic cerebral lesions with survival periods of eight months, two years and three years. As further evidence in support of operative intervention, he cited a case of a cervical cord meningioma, wrongly diagnosed as metastatic carcinoma because of previous malignancy. Fortunately, the patient was operated upon and the benign tumor removed. This is a striking example of the fact that

Submitted for publication March 24, 1938.

a primary tumor of the central nervous system may occur in a patient with a past history of malignancy. A similar case was reported by Meagher and Eisenhardt,[4] an intracranial meningioma being removed eight months after a radical mastectomy for carcinoma with axillary metastases.

Concerning the question of symptomatic relief, it is rather difficult to obtain a definite answer from a review of the recent literature, since full case reports are not usually given. However, it is fortunate that we may turn to the experiences of Doctor Cushing,[5] from whose clinic both Grant's and Oldberg's cases were collected. The statement, "Operations, nevertheless, may not infrequently afford a vast degree of symptomatic relief for which patients and their relatives are most grateful," leaves little doubt regarding the operative relief of symptoms. In addition, he contributes a case of a metastatic carcinoma from the lung with what is probably the longest survival period on record, namely, seven years from the onset of cerebral symptoms and almost six years from the first operation!

The factor of operative mortality again necessitates recourse to Doctor Cushing.[5] Thirty-nine cases were operated upon 50 times with 15 fatalities. The operative mortality of 30 per cent was due largely to the prolonged hospitalization of these patients. It appears likely that this operative mortality has been reflected in the low survival periods reported by Grant.

The evidence just presented could hardly be interpreted as a contraindication to operative attempts upon these unfortunate patients. On the contrary, from the criteria set up at the beginning of this paper, the recent literature must be viewed in a light favorable to surgery. Symptomatic relief, which is perhaps the most important consideration, is specifically noted by both Cushing and Grant. Concerning the duration of life, it must be stated that average survival figures may be misleading by failing to show the extremes of a series. The single case of six years' postoperative life mentioned by Cushing emphasizes the possibility of material prolongation. The operative mortality is not out of proportion to that in glioblastoma multiforme, previously mentioned. Finally, the possibility of disclosing a benign primary tumor must be remembered.

Of secondary interest in the present report is the primary source of the metastases. In the series of 40 intracranial metastatic carcinomata, reported by Meagher and Eisenhardt,[4] 25 per cent were primary in the breast, 35 per cent were of pulmonary origin and the primary focus was unknown in 25 per cent. The high incidence of origin in the breast and lung naturally raises the converse question of how frequently these specific tumors metastasize to the brain.

Lenz and Fried[6] found evidence of brain metastases in 21 per cent of 168 cases of fatal breast carcinomata. However, exclusion of those patients in whom skull metastases were likewise present reduced the incidence to 7 per cent. Applying this figure to an estimated five-year-mortality rate of 59 per cent, obtained from the combined figures of Claiborn and Foster,[7] Cathcart,[8] McClure and McGraw,[9] Saltzstein,[10] and Harrington,[11] gives a calcu-

lated incidence of about 4 per cent brain metastases without skull involvement from carcinoma of the breast. The composite statistics of Dosquet,[12] Seyforth,[13] Levy-Simpson,[14] Fried and Buckley,[15] and Davison and Horwitz[16] indicate an occurrence of about 51 per cent brain metastases in cases of primary carcinoma of the lung.

Another question which naturally arises is the relative frequency of solitary and multiple brain metastases. The autopsy series suggest that at least 70 per cent of these metastases are multiple. However, from the symptomatic aspect the proportion is undoubtedly more nearly equal.

Finally, the interval between the appearance of the primary neoplasm and the onset of intracranial symptoms deserves brief consideration. In the breast metastases recorded in Meagher and Eisenhardt's[4] series, this period varied between the extremes of three months and almost 12 years.

The present report is based upon 14 cases of carcinomatous metastases to the brain, treated by surgical extirpation. The metastatic nature of the lesion was suspected preoperatively in five patients. The malignant character was recognized only after microscopic examination in four cases. The surgical procedures were based upon our established policy for the treatment of primary brain tumors, namely, an extirpation as radical as appears consistent with a satisfactory functional result. Epithelial neoplasms frequently lose many of their malignant characteristics in the foreign environment of the nervous system and assume the appearance of a benign encapsulated lesion. However, necrosis and edema may extend for some distance into the surrounding brain.

CASE REPORTS*

Case 1.—J. N., white, male, age 31, was admitted to the hospital October 29, 1929, complaining of headache, and nausea and vomiting, of six weeks' duration. Following in close succession were weakness of the left extremities, retardation of mental processes and generalized weakness. Hospitalization elsewhere, four weeks after onset, revealed slight papilledema, left hemiparesis, right anosmia and mental dulness.

These findings were confirmed on admission to the New Haven Hospital. In addition, there were hyperactive deep reflexes on the left, and inability to sit up. Roentgenograms of the skull were negative. Ventriculography, October 31, 1929, demonstrated what appeared to be a multilocular cystic glioma in the right frontal lobe.

Operation, November 6, 1929, through a right frontal bone flap, revealed a relatively discrete tumor in the superior frontal region. The tumor, about 7 cm. in diameter, was extirpated. Convalescence was uneventful and the metastatic nature of the lesion was not suspected until microscopic sections were studied.

Pathologic Examination.†—The characteristic cells were large with pale, foamy cytoplasm and large round nuclei, forming perfect glandular acini. Mitoses were frequent, and extensive necrosis was present in the surrounding brain tissue. *Pathologic Diagnosis:* Adenocarcinoma.

Roentgenologic examination of the chest showed a possible primary carcinoma in the

* General physical examination was negative for signs of malignancy in all cases unless otherwise noted.

† The pathologic examinations and diagnosis in all of the 14 cases reported herewith were made by Dr. H. M. Zimmerman, of the Department of Pathology, Yale University School of Medicine.

upper lobe of the left lung. The gastro-intestinal tract was negative for malignancy. The patient was discharged November 27, 1929, completely relieved of symptoms.

Subsequent Course.—Improvement continued for three months, during which time he gained weight and returned to work. Death occurred September 29, 1930, almost 11 months after operation.

Case 2.—H. A., white, male, age 63, was admitted to the hospital November 11, 1929, complaining of headache, vomiting and dizziness of four months' duration. More recently there had been unsteadiness of gait, transient diplopia, blurring of vision and pain in the left ear. Neurologic examination revealed bilateral papilledema, suboccipital tenderness, staggering gait and moderate ataxia of the left arm and leg. Roentgenologic examination of the skull was negative.

Operation, November 20, 1929, disclosed a discrete tumor in the left cerebellar hemisphere; a grossly complete removal was effected. Convalescence was rather slow but essentially uneventful.

Pathologic Examination.—Microscopically, the tumor presented many irregular glandular alveoli composed of cuboidal, dark staining cells. *Pathologic Diagnosis:* Adenocarcinoma, possibly prostatic in origin.

Subsequent Course.—Reexamination of the prostate was negative for malignancy. Gastro-intestinal series likewise failed to disclose the primary source of malignancy but roentgenologic examination of the chest showed metastatic involvement of both lungs. He was discharged, very much improved, December 20, 1929. Death occurred April 18, 1930, five months after operation.

Case 3.—A. K., white, female, age 52, was admitted to the hospital May 28, 1930, complaining of weakness, vomiting, dizziness, headaches and unsteadiness of four months' duration. In 1926 a carcinoma of the right breast was treated elsewhere by simple mastectomy and radium application. Axillary metastases were noted in May, 1929, receiving interstitial radium therapy on two occasions.

Neurologic examination showed blurring of the optic disks, nystagmus, and left-sided cerebellar signs. Roentgenologic examinations of the chest, skull and gastro-intestinal tract were negative for malignancy.

Operation, July 7, 1930, disclosed a firm tumor in the left cerebellar hemisphere. Subtotal removal of the tumor was followed by a rapid relief of all symptoms.

Pathologic Examination demonstrated columns of epithelial cells with abundant mitoses. There was considerable necrosis in the adjacent cerebellar tissue.

Subsequent Course.—She left the hospital July 25, 1930, and remained in excellent condition until about two weeks before her death which occurred in December, 1930, five months after operation.

Case 4.—M. M., white, male, age 52, was admitted to the hospital January 26, 1931, complaining of right temporal headache, blindness of the right eye, difficulty in speech, right facial paralysis, and deafness of the right ear during the preceding ten months. In March, 1930, a mass removed from the right cervical region proved to be metastatic carcinoma. The positive neurologic findings included involvement of all the cranial nerves on the right, bilateral papilledema, weakness of both external recti and bilateral cervical masses. Roentgenologic examinations of the skull and chest were negative.

Operation.—February 10, 1931: A right subtemporal decompression was effected, and a tumor was partially removed from the region overlying the trigeminal ganglion.

Pathologic Examination.—Microscopically, the neoplasm was composed of solid cords of large oval cells with vesicular nuclei. There were no intercellular bridges or epithelial pearls.

Subsequent Course.—He was discharged April 5, 1931, somewhat improved, but still complaining of pain in the right trigeminal area. This was partially relieved by alcohol injection. The patient was readmitted June 9, 1931, because of intractable pain in the right trigeminal field. The right trigeminal roots were avulsed through the usual temporal approach, June 10, 1931. Carcinomatous involvement of the roots and ganglion

was demonstrated microscopically. Postoperative roentgenologic examinations of the esophagus and stomach were negative, and he was discharged June 18, 1931, very grateful for the relief of pain.

He was again admitted July 13, 1931, because of pain in the right ear, conjunctivitis and keratitis. Reexamination still failed to reveal the primary source of the carcinoma. The larynx and nasopharynx showed no evidence of malignancy, though in spite of this the latter would appear to have been the most likely primary site. Death occurred October 28, 1931. Considerable symptomatic relief had been obtained over a period of eight months following the first operation, but the patient was never able to resume work.

Case 5.—J. B., white, female, age 60, was admitted to the hospital July 2, 1931, complaining of right facial pain for the previous three months. During the last month, headache and diplopia had appeared. Examination disclosed bilateral blurring of the optic disks and involvement of the right fifth and sixth nerves. There was roentgenologic evidence of erosion of the clinoid processes, and the sphenoid sinus.

Operation.—July 14, 1931: Exploration of the middle fossa revealed a tumor invading the trigeminal ganglion and floor of the skull and extending through the dura. The trigeminal roots and a portion of the ganglion were avulsed and a partial extirpation carried out on the subdural portion of the tumor.

Pathologic Examination.—Microscopically, the neoplasm presented cores of epithelial cells in a dense connective tissue stroma. There were no intercellular bridges or epithelial pearls.

Subsequent Course.—Search for a primary focus of the carcinoma was unsuccessful, and the patient was discharged August 10, 1931, completely relieved of headache and trigeminal pain. She died October 27, 1931. The period of satisfactory palliation of symptoms was about three and one-half months.

Case 6.—E. B., white, male, age 43, was admitted to the hospital November 9, 1931, complaining of attacks of weakness in the lower extremities followed by severe headache, vomiting, diplopia, transient blindness in the right eye and dizziness of two months' duration. Examination disclosed bilateral anosmia, bilateral papilledema, right sixth nerve paresis, left facial weakness, slight weakness and ataxia of the left upper extremity. Roentgenologic examination of the skull showed a shift of the pineal gland to the left.

Operation.—November 14, 1931: Exploration through a right frontal bone flap revealed what appeared to be an olfactory groove meningioma. The tumor and its dural attachment were removed completely and the true nature of the lesion was not suspected until microscopic sections were studied.

Pathologic Examination disclosed sheets of large epithelial cells, with pale, round nuclei, many in mitosis. Occasional acini were lined with tall columnar, ciliated cells containing blepharoplasten. *Pathologic Diagnosis:* Carcinoma arising from accessory nasal sinuses.

Subsequent Course.—Convalescence was complicated by a nasal, cerebrospinal fluid leak. After a series of roentgen treatments directed at the nasal sinuses, he was discharged December 11, 1931, relieved of symptoms. He died May 15, 1932, six months after operation.

Case 7.—L. M., white, female, age 45, was admitted to the hospital August 10, 1932, complaining of headache, vomiting, and dizziness of five months' duration. The significant findings were drowsiness, rigidity of the neck, bilateral papilledema and bilateral sixth nerve paresis. Roentgenologic examinations of the skull and chest were negative. Ventriculography, August 16, 1932, demonstrated an internal hydrocephalus involving the lateral and third ventricles.

Operation.—August 18, 1932: Cerebellar exploration disclosed a vascular tumor within the left cerebellar hemisphere having the appearance of a meningioma. The tumor was partially removed.

Pathologic Examination.—The tissue was composed of columns of large epithelial

cells, frequently forming small acini, the lumen of which contained pink-staining material resembling the colloid of normal thyroid gland. *Pathologic Diagnosis:* Adenocarcinoma, metastatic, from the thyroid gland.

Subsequent Course.—Postoperative examination of the thyroid was negative, but before leaving the hospital a small mass became palpable in the region of the liver. She was discharged September 7, 1932, relieved of her original complaints. She died September 10, 1932, three weeks after operation.

Case 8.—M. W., white, female, age 51, was admitted to the hospital November 2, 1933, complaining of convulsions, difficulty in speech, paresthesias in the left upper extremity, headache and vomiting beginning eight months previously. A left radical mastectomy had been performed for carcinoma four and one-half years previously. The positive findings were bilateral papilledema, right sixth nerve paresis, asteriognosis of the left hand. Roentgenograms of the skull were negative.

Operation, November 9, 1933, disclosed a tumor in the right parietal region.

Pathologic Examination.—Microscopically, the neoplasm was composed of tall, columnar, epithelial cells forming large, irregular acini. Many mitotic figures were present. *Pathologic Diagnosis:* Metastatic adenocarcinoma.

Subsequent Course.—The patient was discharged November 29, 1933. She was never able to resume her previous activity, but remained fairly comfortable until her death, January 20, 1934, two months after operation.

Case 9.—T. C., white, female, age 45, was admitted to the hospital March 10, 1934, complaining of headache, vomiting and blurring vision of eight months' duration, associated with unsteadiness during the past two weeks. She was operated upon elsewhere in 1928, when a "cancer of the intestine" was removed. Positive findings were bilateral papilledema, left sixth nerve paresis, and cerebellar signs lateralized to the left. There were two lower abdominal scars and a small mass in the left breast which did not have the characteristics of carcinoma. Roentgenologic examinations of the skull and chest were negative for metastases.

Operation, March 12, 1934, disclosed a tumor within the left cerebellar hemisphere. This was completely removed.

Pathologic Examination.—Microscopically, the tumor was composed of large cells with hyperchromatic nuclei, arranged in acini and solid columns. Mitotic figures were numerous.

Subsequent Course.—The patient was discharged March 24, 1934, relieved of symptoms, and was able to resume many of her household activities until shortly before her death, in December, 1934, nine months after operation.

Case 10.—A. S., white, female, age 44, was admitted to the hospital June 4, 1934, complaining of unconsciousness, headaches, vomiting and mental dulness during the preceding eight months. The positive findings were bilateral papilledema, right homonymous lower quadrant anopsia, and the presence of several firm nodes in the left supraclavicular region. Roentgenologic examinations of the skull and chest were negative for malignancy. Ventriculography, June 9, 1934, demonstrated displacement of the ventricular system to the right. The ventricular fluid contained large epithelial cells, sometimes in small groups.

Operation.—June 11, 1934: Removal of a left occipitoparietal bone flap disclosed a cyst in the occipital lobe, containing peculiar, pale yellow, milky fluid. A firm nodule was removed from the cyst wall.

Pathologic Examination.—Microscopically, the neoplasm was composed of sheets of large cells, some of which had definite polygonal cellular membranes while others appeared to have a syncytial arrangement. The nuclei appeared as large vesicular bodies in an abundant wine-colored cytoplasm.

A lymph node, removed from the left supraclavicular region, June 23, 1934, was diagnosed as squamous cell carcinoma. Roentgenograms of the chest and entire gastrointestinal tract were negative for malignancy.

Subsequent Course.—Convalescence was complicated by a thrombophlebitis of the left femoral vein, which delayed her discharge until August 1, 1934. She was able to carry on quite well during her first two months at home. She died December 2, 1934, six months after operation.

Case 11.—E. L., white, female, age 59, was admitted to the hospital May 6, 1935, complaining of dizzy spells, loss of memory and interest of seven months' duration. Examination disclosed mental dulness and lethargy, apraxia, slight aphasia and bilateral papilledema. Roentgenograms of the skull were negative.

Operation.—Immediately following ventriculography, May 10, 1935, which indicated a lesion in the left frontal lobe, a left frontal bone flap was raised and a tumor removed from beneath the corpus callosum.

Pathologic Examination.—Microscopically, the tissue exhibited considerable cellular polymorphism. Many cells were of enormous size with pale, ground glass cytoplasm and huge bizarre hyperchromatic nuclei, in places forming sheets, in other lying singly in extensive pools of hemorrhage. Both mitotic and amitotic division were in evidence. *Pathologic Diagnosis:* Metastatic carcinoma, resembling chorio-epithelioma.

Subsequent Course.—Pelvic examination and roentgenologic studies of the chest were negative for malignancy. She was discharged May 25, 1935, but was never able to completely regain her normal activity at home, and after several months she became aphasic and confined to bed. She died November 22, 1935, six months after operation. A partial autopsy, limited to the abdomen and performed elsewhere, failed to reveal the primary source of malignancy.

Case 12.—J. A., white, female, age 48, was admitted to the hospital December 13, 1936, complaining of headache, vomiting and mental dulness for two weeks. Antedating these symptoms by two weeks, there had occurred a brief attack of syncope during which a scant, fresh rectal hemorrhage occurred. Examination revealed bilateral papilledema, left pupil larger than the right, negative rectal and general physical examination. Roentgenograms of the skull were negative except for minimal evidence of increased intracranial pressure.

Operation, immediately following ventriculography, December 15, 1936, which demonstrated an internal hydrocephalus involving the lateral and third ventricles, a cerebellar exploration, disclosed a tumor within the cerebellar vermis. A subtotal removal of the tumor was accomplished.

Pathologic Examination.—Microscopically, the neoplasm presented the picture of a highly malignant cylindrical cell carcinoma, forming acini. Mitoses were frequent, and the cells were arranged in layers around central spaces resembling a carcinoma from the lung or gastro-intestinal tract.

Subsequent Course.—This patient did very poorly after operation and was never able to be out of bed. The stools showed a positive guaiac test on two occasions. She was transferred to another hospital, January 7, 1937, where she died January 14, 1937, one month after operation.

Case 13.—L. H., white, male, age 47, was admitted to the hospital November 8, 1937, complaining of headache, convulsions, failing memory, olfactory and visual hallucinations of two months' duration. A perforated peptic ulcer had been operated upon 20 years previously, and recurrent episodes of epigastric pain and vomiting had been present during the past ten years. Examination revealed blurring of the optic disks, transient bilateral Babinski and tremor of the hands. Spinal fluid pressure was elevated and the Pandy reaction was four plus. Roentgenograms of the skull were negative. Gastro-intestinal series in another hospital, seven weeks earlier, were reported as negative except for evidence of "adhesions at the pylorus." Ventriculography, November 19, 1937, disclosed xanthochromic fluid in the right lateral ventricle; the third ventricle was displaced to the left.

Operation.—December 2, 1937: A cyst in the right frontal lobe was disclosed, which

contained 40 cc. of xanthochromic fluid. A tumor, extending along the wall of the third ventricle, was partially removed, together with the cyst wall.

Subsequent Course.—Convalescence was satisfactory until the sixth postoperative day, when drowsiness and fever developed. The bone flap was reelevated and a sizable extradural clot evacuated. During the succeeding week signs of bilateral pulmonary involvement appeared and there was copious "coffee-ground" vomiting on several occasions. Death occurred December 15, 1937, 13 days after operation.

Pathologic Examination.—The brain tumor was composed of columnar epithelial cells, forming acini; many of the cells were of the goblet type and mitoses were present.

Autopsy revealed adenocarcinoma of the pylorus with metastases to the left lung, bilateral pneumonia, rupture of the esophagus with gastric contents in the right pleural cavity and right fibrinopurulent pleurisy. The brain contained numerous metastatic lesions varying from microscopic size to 5 cm. in diameter and filled (Fig. 1) with mucoid material.

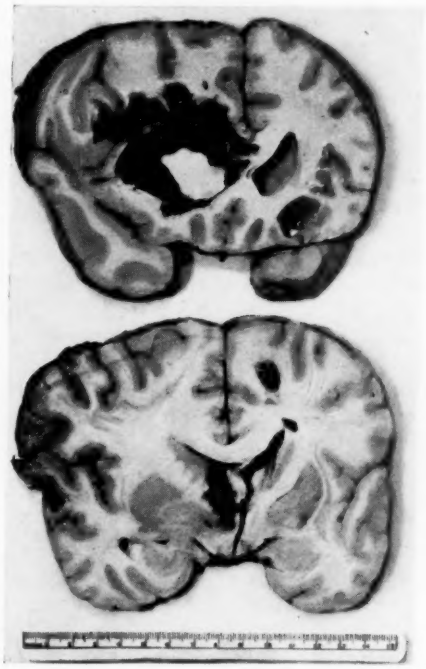

FIG. 1.—Case 13: Cross-section of brain showing site of tumor extirpation and several smaller metastatic nodules.

Case 14.—M. N., white, female, age 34, was admitted to the hospital January 4, 1938, complaining of right-sided weakness and convulsions beginning two months previously. A mass in the left breast, of two years' duration, had been concealed by the patient from her physicians' attention. Examination revealed blurring of the optic disks, right hemiparesis, minimal right hypesthesia, and a firm, fixed mass in left breast with axillary metastases. Roentgenograms of the skull were negative. A film of the chest, however, demonstrated a destructive lesion in the right ninth rib.

Operation, January 6, 1938, disclosed a discrete, subcortical tumor in the left prefrontal region. The tumor was removed in one mass.

Pathologic Examination.—Microscopically the sections of the tumor showed it to be composed of columns of poorly differentiated epithelial cells, many of which were in mitosis. *Pathologic Diagnosis:* Metastatic carcinoma, primary in breast, showing, however, but very little evidence of definite cellular differentiation.

Subsequent Course.—The carcinoma of the breast was treated by radium implantation, 7,500 mg. h., and she was discharged, February 15, 1938, 40 days after operation. Four weeks later her condition was excellent except for pain in the right arm.

Discussion.—Evaluating the preceding cases in the light of the criteria set up at the beginning of this paper, it would appear that operation is not only justifiable but definitely indicated. All cases but two had at least partial relief of symptoms for periods of three weeks to eight months following operation. One-half of them were able to carry on their usual activities. The postoperative survival periods varied from three weeks to 11 months, the average being five months plus. The life expectancy following operation can be best appreciated by reference to Chart 1. The operative mortality for this

TABLE I

RÉSUMÉ OF 14 CASES OF CARCINOMATOUS METASTASES TO THE BRAIN

Case No.	Sex	Age	Duration of Symptoms	Time in Hospital*	Postoper. Survival Period	Period of Symptomatic Relief	Previous History of Carcinoma	Interval between Primary and Secondary	Primary Source		Location of Brain Metastases
									Clinical Impression	Pathologic Impression	
1	M.	31	1½ mos.	45 days	11 mos.	4 mos.	None	—	Lung	Kidney or G.I. tract	Frontal, right
2	M.	63	4 mos.	39 days	5 mos.	?	None	—	Unknown	Prostate	Cerebellum, left
3	F.	52	4 mos.	58 days	5 mos.	4½ mos.	Breast	4 yrs.	Breast	Breast	Cerebellum, left
4	M.	52	10 mos.	185 days	8½ mos.	5 mos.	Metastases to cervical nodes	1 yr.	Nasopharynx	Nasopharynx	Temporal, right
5	F.	60	3 mos.	39 days	3½ mos.	3½ mos.	None	—	Nasopharynx (?)	Nasopharynx	Temporal, right
6	M.	43	2 mos.	33 days	6 mos.	6 mos.	None	—	Nasal sinuses	Nasal sinuses	Frontal, right
7	F.	45	5 mos.	28 days	3 wks.	3 wks.	None	—	Unknown	Thyroid	Cerebellum, left
8	F.	51	8 mos.	27 days	2 mos.	Never complete	Breast	4½ yrs.	Breast	Breast	Parietal, right
9	F.	45	8 mos.	14 days	9 mos.	8 mos.	"Intestine"	6 yrs.	Colon	G.I. tract	Cerebellum, left
10	F.	44	8 mos.	62 days	6 mos.	3½ mos.	None	—	Lung(?)	Lung(?)	Occipital, left
11	F.	59	7 mos.	19 days	6 mos.	Never complete	None	—	Unknown	Chorio-epithelioma	Frontal, left
12	F.	48	1 mo.	25 days	1 mo.	0	None	—	Colon	Lung or G.I. tract	Cerebellum, vermis
13	M.	47	2 mos.	37 days	13 days	0	No. Peptic ulcer	—	Unknown	Stomach	Frontal, right. Multiple in cerebrum
14	F.	34	2 mos.	42 days	Still living (2 mos.)	Still present (2 mos.)	Breast	2 yrs.	Breast	Breast	Frontal, left
Average		48.1	4.7 mos.	47 days	5.1 mos. plus						

* Includes total time in cases with multiple hospitalizations.

series was 7 per cent. However, it is only fair to state that Case 12 escaped being classified as an operative death only by virtue of the fact that she died in another hospital, to which she was transferred at her family's request. All the other cases were able to return to their homes.

Concerning the primary source of the neoplasms, it is impossible to give an entirely satisfactory answer in four instances (Cases 2, 5, 7 and 11). Three cases (Nos. 3, 8 and 14) gave a previous history of carcinoma of the breast. One patient (Case 9) had an "intestinal" resection for carcinoma, presumably of the colon. Another (Case 4) had nodes of the neck removed for carcinomatous metastases, possibly from the nasopharynx. Finally, one patient

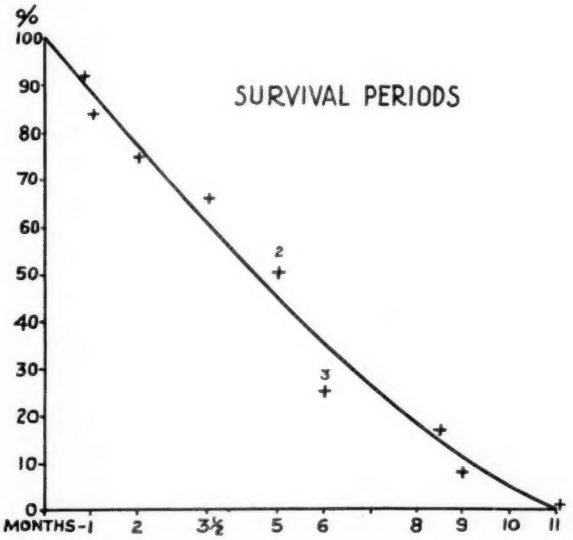

CHART 1.—Survival periods of Cases 1 to 12; Case 13 (fatality) and Case 14 (still living) are not included. The numbers "2" and "3" indicate two and three deaths at five and six months, respectively.

(Case 10) had carcinoma metastases verified postoperatively in the supraclavicular nodes, perhaps secondary to a primary lesion in the lung, which, however, could not be demonstrated roentgenographically. Postoperative attempts to determine source of malignancy were unsuccessful except in Case 1, where a presumptive carcinoma of the lung was revealed roentgenologically. Case 6 obviously arose in the accessory nasal sinuses as evidenced by communication through the cribriform plate and the presence of ciliated epithelium. Case 12 probably had the primary lesion in the colon on the basis of previous bleeding from the rectum and the microscopic appearance of the tumor. The pathologic picture in Case 2 suggested prostatic origin, though this could not be confirmed by digital examination. Similarly, the thyroid was implicated in Case 7 but palpation failed to reveal any abnormality.

However, these two sites—prostate and thyroid—are known to harbor small areas of carcinoma which may give rise to early metastases. It is perhaps pertinent in this connection that both patients had extensive metastases elsewhere: both lungs in Case 2 and the liver in Case 7. The nasopharynx is suggested as the primary site in Case 5 because of the clinical and pathologic similarity to Case 4. Autopsy confirmation in Case 13 revealed a carcinoma of the stomach with multiple metastases to the lung and brain. Finally, the tumor in Case 11 resembled a chorio-epithelioma, though pelvic examination and partial autopsy failed to confirm this. In the four cases with a history of previous primary malignancy, the intervals preceding admission for brain metastases were two, four, four and one-half and six years.

Certain other facts of interest are illustrated in Table I. In this series females outnumbered males nine to five. The average age was 48.1 with extremes of 31 and 63. The distribution by age decades is shown in Table II.

TABLE II

DISTRIBUTION BY AGE DECADES

Decade	4th	5th	6th	7th
Patients	2	6	4	2

Regarding the location of the brain metastases, it is somewhat surprising to find the cerebellum involved in five cases in spite of its relatively small size. All lobes of the cerebrum were represented, the frontal in four cases. The only peculiarity of lateralization was the fact that the right cerebral hemisphere was involved more often than the left (5:3), while the right cerebellar hemisphere was never implicated (0:4; 1 in vermis). Multiple metastases in both cerebral hemispheres were found at autopsy in one case.

Finally, consideration of the period of hospitalization is of some importance. The average was 47 days with extremes of 14 and 185! This latter figure included three separate hospitalizations ending in a long terminal illness because the patient could not be cared for adequately at home. However, even excepting this unusual instance, there was too much time spent in the hospital, both before and after operation. Reference to Chart 1 illustrates that the life expectancy at best is in the neighborhood of one year and that 50 per cent of these patients will probably be dead within six months. Further, their period of greatest usefulness is likely to be shortly after operation. With these economic factors in mind, it does not seem justifiable to prolong hospitalization in the hope of locating the primary site, since curative therapy is out of the question. This is further emphasized by the fact that such studies revealed the primary focus in only one case of this series. If general physical examination and roentgenologic studies of the chest are negative, it is probably wiser to concentrate on an attempt to obtain a postmortem examination when death occurs.

SUMMARY AND CONCLUSIONS

Fourteen cases of metastatic carcinoma of the brain are reviewed and analyzed in respect to operative results. The period of symptomatic relief varied from zero to eight months; one-half of the patients were able to resume their usual activities. The postoperative survival periods varied from three weeks to 11 months, with an average of five months plus. The operative mortality was 7 per cent.

The probable primary sources of the neoplasms were: Breast, three; lung, two; colon, two; nasopharynx, two; prostate, one; thyroid, one; accessory nasal sinuses, one; stomach, one; and chorio-epithelioma (?), one.

The distribution of patients in respect to sex was females nine, males five. The average age was 48.1 with extremes of 31 and 63.

The metastases were located in the cerebrum in nine instances and the cerebellum in five. One case had multiple cerebral metastases.

The period of hospitalization averaged 47 days with extremes of 14 and 185. It is suggested that every attempt be made to shorten this period because of the limited life expectancy.

The conclusion is drawn that operation is definitely indicated in patients with metastatic carcinoma of the brain if the metastases are apparently solitary.

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EPIDURAL SPINAL INFECTIONS *

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DANDY,[1] in 1926, collected 25 cases of epidural abscess from the literature, and added three cases of inflammatory tumors (one tuberculous) to seven previously reported. Five of these were probably of syphilitic or tuberculous origin. The largest group of epidural abscesses personally observed, was published by Mixter and Smithwick,[2] in 1932, who reported 10 cases. Browder and Meyers,[3] in 1937, reported on seven patients, five of whom had abscesses and two inflammatory tumors. This article contains a very complete bibliography and a tabulation of 88 cases, which include both the acute abscesses and the granulomata, and represents all cases recorded from 1855 to 1937, indicating the comparative infrequency of such infections. In the present communication we wish to report seven cases, five of acute epidural suppuration and two of granulomata. Neither tuberculous nor syphilitic infections are under discussion.

Etiology.—There may be some question of the advisability of considering the more or less chronic granulomata with the acute abscesses. They seem, however, to other observers and to me, to have a common etiology. Infections of the epidural space are considered to occur by direct spread from contiguous structures or by metastasis from a distant focus. When there is a direct invasion from a neighboring infected structure, such as a vertebra or rib, the mechanism is readily understood and is not debatable. In the larger group, which is more important and more difficult to diagnose, the infection arises as a metastasis from a distant lesion, such as a furuncle or an infection of a finger, which may have healed and been forgotten before the onset of the spinal symptoms. Many observers have felt that in most instances the metastatic infection is to the epidural spinal fat. Browder and Meyers hold with some others that the hematogenous variety most likely always metastasizes to the vertebra whence it spreads into the epidural space. The evidence they present is very suggestive, especially the postmortem findings of vertebral involvement. As they correctly observe, a small area of osteomyelitis might readily be overlooked at operation. Where there is as extensive a bone lesion as is described by these authors, there is every probability that the epidural space was involved secondarily. It is, however, possible for the vertebra to be invaded from without. The microscopic study of the bone removed in Case 4, suggested this spread; though it does not, of course, rule out an overlooked primary focus in a neighboring vertebra. The stump of a lamina in Browder and Meyers' Case 7 was probably secondarily invaded.

* Read before the New York Surgical Society, October 26, 1938. Submitted for publication June 8, 1938.

Pathology.—Once involved, whether from a metastasis to the epidural fat or by spread from a vertebra, the lesion in the epidural space is made up of a varying amount of free pus and granulation tissue. The pus may be large in amount and extend from the cervical to the lumbar region, and there may be no granulation tissue. On the other hand, the granuloma may be the only evidence of a chronic infection. There may or may not be droplets of pus in it, or the combination of considerable granulation tissue and a large amount of free pus may exist. The inflammatory tumors, chronic granulomata, are found beneath the site of a previous skin infection or of trauma to the back. Where there is free pus only, the dura is reddened though it preserves very often its normal luster. Where granulations exist they are attached to the dura, on its dorsal and lateral aspects. In the acute cases this attachment is not as intimate as is found in the granulomata where sharp dissection is necessary to free the dura. The fact that there is an actual space between the vertebra and the dura dorsally, allows the pus to spread upward and downward, while the dura itself acts as an effective barrier to the invasion of the subarachnoid space. On the anterior aspect, however, as other observers have pointed out, the dura is intimately attached to the posterior bodies of the vertebra. A large extradural collection of pus is not encountered and perforation into the subarachnoid space is more frequent.

The seriousness of the disease is the damage done to the spinal cord. In the few cases where careful histologic studies of the cord have been reported (Ayer and Viets,[4] and Hassin[5]), the changes noted have been out of proportion to the pressure of the abscess. There have been noted areas of rarefaction, vacuoles, destruction of fiber tracts and cells. Elsberg[6] explains the findings on the basis of local interference with the circulation of blood in the cord. Browder and Meyers state, in Case 3, "Many blood vessels of the cord were thrombosed, being filled with septic thrombi."

Symptoms.—In the acute cases the history given by the patients is very uniform and the course of the disease varies but little and that only in its time elements. The onset is marked by pain in the back. The site of the pain varies with the location of the lesion. If in the rare instance of a process in the cervical region, the pain will be in the back of the neck, radiating up to the occiput and down into the arms; if low in the thoracolumbar spine the pain will be low in the back with early radiation down the legs. The most frequent site is in the interscapular region, or a little lower, with radiation around to the anterior part of the chest or upper abdomen. The pain should not be referred to just as pain and passed over; it is probably one of the most excruciating pains in the back that a patient can have. It is more or less constantly present and seemingly ever increasing in severity. It is not relieved by the recumbent posture. In fact, many of these patients cannot lie down. Morphine hardly seems to control the agony.

During this period the temperature is usually elevated, but its degree varies considerably. It may reach 103° to 104° F. or not go above

100° to 101° F. In from a few days to about two weeks, neurologic signs make their appearance. While the most frequent early complaint is tingling or numbness in the legs, weakness in the legs or bladder disturbances may be the first sign. The rapidity with which the paralysis progresses varies. It may go on to a complete flaccid paraplegia within a few hours (almost minutes) after the onset, or it may take several days to reach this stage. During this time there will be a weakness gradually increasing in one leg, then involvement of the other. In fact, patients have been reported with a flaccid paralysis of one leg and a spastic paresis of the other. In a very few cases the motor changes may be limited to a foot drop, to a weakness of one leg or to spastic paresis of both legs. But the rule is for a rapid progression to the stage of flaccid paraplegia.

An analysis of the time of onset of the neurologic signs from the beginning of pain in the back was possible in 49 reported cases of metastatic abscesses. In 14 cases the interval was five days or less, in 19 cases the first neurologic sign appeared between the sixth and tenth day, in 10 cases between the eleventh and fifteenth day, and in six cases it was over 15 days. The very short interval in some cases indicates the primary invasion of the epidural space and prompt interference with the vascular supply of the cord.

The sensory findings are not as constant as the motor, though most often there will be found loss of all sensation below the level. There are, however, cases in which the motor signs are much more marked than the sensory. At times the sensory level will be found to extend upward from day to day. Early loss of sphincteric control is common. Tenderness over the spine at the site of the lesion is a constant finding.

Two additional observations are of help in arriving at a diagnosis. The white blood count is elevated, with an increase in the polymorphonuclear cells. Lumbar puncture yields further information. If a manometric determination is made, there will be block on jugular compression. The fluid is often xanthochromic, though it may be clear. The total protein content is high and there may be, though not necessarily so, a pleocytosis.

More than a word of caution is needed in advocating lumbar puncture. Regardless of the site of origin in the canal of the infection, many patients will have pus in the epidural lumbar space because of a gravity abscess. This was encountered in three of the five patients in the present series. There exists, then, the obvious danger of traversing the layer of pus and infecting the subarachnoid space, initiating a meningitis. If the diagnosis be suspected, the stilet should be removed from the needle after the skin has been traversed. In this way pus would be obtained before the dura is reached.

In the granulomata the evolution is less rapid and more closely resembles that of cord compression from a tumor. The pain, while less than in the abscess cases, is much more severe than that seen in spinal cord tumors except some of the giant tumors of the cauda equina.

CASE REPORTS

Case 1.—Barnert Hospital, Paterson, N. J., No. 31274: P. F., male, age 16, was admitted to hospital August 24, 1930. On August 18, 1930, a superficial abscess had been incised over the knee. Twenty-four hours later he developed pain in the lower abdomen and chest. Two days later the neck became painful and was held rigidly. The temperature on admission was 104.2° F. The neck was rigid and a positive Kernig sign was noted. W. B. C., 42,000; polymorphonuclears, 90 per cent. The spinal fluid contained one cell and what appeared to be Cocci. Though the culture was negative, antimeningococcus serum was given. Culture of fluid, obtained the following day, was also negative. On August 26, no fluid was obtained on two attempts. The following day a few drops of pus were obtained from the lumen of the needle introduced into the lumbar region and clear fluid with 17 cells from the cisterna. There was weakness of the legs, tenderness and fulness over the upper thoracic spine, and roentgenologic evidence of bone destruction of the arch of the fourth thoracic spine. Laminectomy revealed an abscess in the soft parts, disease of the fourth spinal arch and free pus in the epidural space. The culture yielded *Staphylococcus aureus*. The patient did not improve following this drainage. He was unable to void, though no new neurologic signs appeared. On September 3, drainage of the lumbar epidural space was instituted by laminectomy. A blood culture, on September 5, yielded *Staphylococcus aureus* in pure culture. The patient died on September 7, 1930.

This type of epidural abscess was secondary to an osteomyelitis of the vertebra, but was only part of a picture of a general sepsis. In the light of further experience the necessity of the second laminectomy is questionable, although when it was carried out considerable undrained pus was observed in the lumbar epidural space.

Case 2.*—Mount Sinai Hospital No. 348583: G. L., male, age 6 months, was admitted to the Pediatric Service, February 1, 1933, because of fever for six days. The temperature range was from 99° to 103° F. On the day of admission rigidity of the neck was noted. This and a questionable injection of the pharynx were the only abnormal physical findings at the time of admission. A lumbar tap the following day yielded xanthochromic fluid which contained 150 cells. W. B. C., 15,200; polymorphonuclears, 46 per cent. Three days later the spinal tap was repeated. At this time only a few drops of xanthochromic fluid were obtained which showed 160 cells, of which 70 per cent were polymorphonuclear in type. On the eighth day after admission, a flaccid paralysis of both upper extremities appeared. Two days later, a spastic paralysis of the lower extremities occurred. About this time, a swelling was noted to the right of the lumbar vertebrae (neurosurgical consultation was requested). Pus was obtained from the epidural region in the third lumbar space, and pressure over the swelling increased the flow from the puncture needle. It was felt that this pus represented a gravity abscess from a lesion originating in the cervical region. However, roentgenologic examination of the cervical spine disclosed no abnormality. An immediate operation was undertaken.

Operation.—The pus in the lumbar musculature was found to communicate with the epidural space in the region of the second lumbar vertebra. The spines and laminae of lumbar II and III were removed and pus was seen in the epidural space pouring down from above. A long drainage tube (subsequently shown roentgenologically, to reach the first thoracic vertebra) was inserted epidurally and the wound packed, wide open. A culture of the pus was reported to contain an hemolytic Streptococcus. Improvement in motor power began six hours after operation and continued until there was normal power

* This case was reported by L. W. Rauh in the Journal of the Mount Sinai Hospital, 1, 13, 1934.

in all extremities. Lipiodol was injected into the tube to determine, if possible, the site of the cervical lesion. It reached the seventh cervical vertebra, but nothing abnormal was seen here. The drainage tube was removed six days after the operation. The boy was seen three and one-half years later and appeared normal.

The origin of this epidural abscess was never determined. All we know is that it probably arose in the cervical and extended to the lumbar region. The surgical procedure, while unorthodox, that is, drainage in the lumbar region, seemed to us to be following the path nature pointed out. In any event, in this instance it was satisfactory. The finding of an hemolytic Streptococcus is somewhat unusual; the majority of such abscesses are due to a Staphylococcus.

The cervical region is least often involved. Of 50 collected cases of metastatic abscess, only four were in this region.

Case 3.—Mount Sinai Hospital No. 390090: R. M., female, age 15, was admitted to the hospital, because of a paraplegia of one day's duration, with an antecedent history of boils of the face and a more recent history of severe back pain. A complete transverse lesion at the tenth thoracic segment was found. Laminectomy disclosed an epidural spinal abscess. No return of function.

During the month prior to the onset of her present illness, she had had many boils of the face. Two weeks before admission she began to have pain in the lower part of the back. At first, she continued at school, but the pain kept increasing in severity so that finally she was unable to lie in bed and found most comfort in the standing position. The morning prior to admission there was a rapid onset of paraplegia and loss of ability to void. Fever had not been noted, and at the time of admission the temperature was 99.6° F. Examination showed a flaccid paraplegia with loss of all sensation and reflexes below the tenth thoracic segment. W. B. C., 20,000; polymorphonuclears, 80 per cent. A spinal tap yielded faintly xanthochromic fluid containing 37 leukocytes; a total protein of 135 mg. per cent; and complete block on manometric determination. A laminectomy was undertaken within an hour after admission. The spines and laminae of thoracic VI and X were removed. A thick layer of granulation tissue covered the posterior dura; in addition there were about 10 cc. of free, thick pus, from which a *Staphylococcus aureus* was cultured. The patient was discharged 65 days postoperative, without any return of function.

Case 4.—Mount Sinai Hospital No. 398729: G. K., male, age 23, was admitted to the hospital, because of pain in the back and fever for three days. Under observation, meningeal signs appeared. Laminectomy revealed an epidural abscess in the lower thoracic region. Recovery.

As a boy this patient had suffered with osteomyelitis of many of the long bones and had had an osteoarthritis of the hip. He had been well, however, for eight years, until two months prior to his present illness, when he began to suffer with furuncles over the body. Some of these, as well as recent scars, were present when he entered the hospital. Three days prior to his admission he began to complain of pain in the lower back, which increased in severity and was associated with fever. A severe headache developed three hours before admission, at which time he had a temperature of 102° F. There was tenderness over the twelfth thoracic spine as well as in the left costovertebral angle. The neck was held rigid, a bilateral Kernig sign was present, and a zone of hyperesthesia was noted over the eleventh and twelfth thoracic dermatones. W. B. C., 16,900; 86 per cent polymorphonuclear cells. On admission two diagnoses were considered—a perinephric abscess and an osteomyelitis of the spine. The following morning the signs remained unchanged. A lumbar tap was considered inadvisable, therefore a cisterna tap was performed, which yielded cloudy fluid containing 2,000 cells with 60 per cent poly-

morphonuclear leukocytes, but no organisms on spread and subsequent culture. An immediate laminectomy from thoracic XI to lumbar I was carried out. This disclosed pus overlying the dura with little granulation tissue. The operative exposure seemed to reach the limits of the infection. The wound was packed wide open. Although the meningeal signs persisted a few days, convalescence was smooth for three weeks, when signs of an abscess in the soft parts of the thigh appeared. This was opened a week later, and the patient went on to a complete recovery. The pus from the epidural space showed Staphylococcus on culture.

Pathologic Examination.—Dr. Paul Klemperer. Specimen: Bone removed at the time of the laminectomy. "There is a very severe, acute purulent inflammation with actual abscess formation on the surface of the endosteal fascia of some of the particles. One can see a purulent inflammatory reaction within the haversian channels. Within the bone marrow one can also see in places very conspicuous purulent inflammation and an increase of polymorphonuclear leukocytes is notable throughout. However, there is no evident bone destruction in the interior of the particles.

"In view of the fact that there is actual abscess formation on the surface, one can hardly understand that the bone would not be severely destroyed, in at least some areas, if this surface reaction would be an extension of the process from the bone to the surface. For this reason I feel certain that one must conclude that the osteomyelitis is secondary to the inflammation on the surface."

In this instance, we were fortunate to have a very early case, before the onset of any neurologic signs other than meningeal irritation. He was operated upon 16 hours after he entered the hospital, just four days from the onset of the back pain. This is the earliest diagnosis and operation that we have found recorded. The case reported by Slaughter, Fremont-Smith and Munro[7] was operated upon five days after the onset, after 66 hours of observation.

Case 5.—Mount Sinai Hospital No. 401224: S. P., male, age 26, was admitted to the hospital with an 11-day history of back pain and a one-day history of weakness of the legs. Immediate laminectomy was performed for drainage of an epidural spinal abscess. Spread of the infection to the anterior mediastinum which was drained one month later. Death.

Three weeks before the onset of pain in the back an infected finger had been incised. The back pain was noted on arising one morning, 11 days before admission to the hospital. The day before admission there was loss of power in the legs and inability to void. During this period he claimed to have been afebrile; on coming to the hospital his temperature was only 99.4° F. He looked sick. There was percussion tenderness over the fourth to sixth thoracic spines. Very slight power remained at the hips and the left knee. There was a sensory level at the seventh thoracic segment below which sensation was diminished. The deep reflexes were still present in the legs and a Babinski sign was found on the right. The neck was slightly rigid and a bilateral Kernig was noted.

A lumbar puncture was carefully performed, the stilet being withdrawn before the dura was penetrated. Slightly xanthochromic fluid was obtained which showed a complete block to jugular compression. There were 30 cells, and the total protein was 90 mg. per cent.

Laminectomy of thoracic IV, V, and VI disclosed a large amount of free pus, under pressure, in the epidural space. The dura was covered with a thick layer of granulation tissue. The wound was packed wide open. The pus showed *Staphylococcus albus* on culture.

During the next few days power began to return in the legs, and sensation improved. Ten days after operation the temperature began to rise. At first no cause could be found.

Later retention of pus was noted in the wound. At a second operation this was found to come from beneath a rib and subsequent roentgenologic examinations showed a prevertebral abscess. This was drained on the Thoracic Service, but the patient succumbed five days later. Postmortem examination revealed multiple pulmonary abscesses and bronchopneumonia.

Cases 6 and 7 illustrate types of inflammatory tumors or chronic granulomata.

Case 6.—Beth David Hospital No. 30-1972: J. K., male, age 65, was admitted to the hospital August 26, 1930, with the history of having been in an automobile accident in February, 1930. The patient had no recollection of a direct blow to the spine though he recalled having been badly shaken up. Four months later, he began to complain of pain in the lower back, which was intensified on coughing or sneezing. For six weeks before his admission, he had noted weakness of the legs, which increased so that he was confined to bed. For four weeks he had difficulty in voiding. When first seen in consultation, September 12, 1930, he had almost complete paraplegia with spontaneous flexion contractions. The deep reflexes in the legs were increased and a bilateral Babinski response could be obtained. The sensory level was about the tenth thoracic segment. The thoracic vertebrae, VIII and IX, were sensitive to pressure. Lumbar puncture demonstrated a complete block.

Operation.—September 13, 1930: Laminectomy disclosed, beneath the thoracic vertebrae VIII and IX, a dense mass of tissue encircling the dura on its dorsal and lateral aspects. This could not be separated from the dura bluntly. It was split in the midline and parts removed by sharp dissection. The pathologic report of the excised mass, verified by Dr. Joseph H. Globus, was chronic granuloma. There was considerable postoperative improvement, so that the patient was able to get around and he could control his sphincter.

The appearance on the operating table was that of an extradural sarcoma; however, it was more dense and adherent than is usually the case in that type of tumor. The very clear-cut traumatic history must be considered as a possible etiologic factor even in the absence of evidence or history of a direct blow.

Case 7.—Mount Sinai Hospital No. 409313: S. W., male, age 44, was readmitted to the general surgical service, three and one-half months after he had been discharged following an operation for a carbuncle of the neck. The infecting organism was a *Staphylococcus aureus*. He had a mild diabetes, which could be readily controlled by dietary regimen. Shortly after he left the hospital he began to complain of pain in the back of the neck which radiated up to the occiput. Flexion and lateral motion of the head and neck were limited by pain. About two weeks before his readmission the pain had become aggravated.

On examination, it was noted that flexion of the neck caused shock-like pains in the legs. The power in the right arm was diminished. The deep reflexes in the lower extremities were increased, the right more than the left, and a Babinski response was obtained on the right. Tenderness was present over the spine of cervical two and three, and an indefinite sensory level seemed to be present at the second cervical segment. The following day the weakness of the right arm had increased. Some weakness appeared in the left arm, and there was retention of urine. A lumbar puncture showed a block, and the fluid contained 104 mg. of total protein. W. B. C., 13,500; 86 per cent polymorphonuclear cells.

A preoperative diagnosis of granuloma was made, which was verified by laminectomy.

The mass lay on the dorsal and lateral aspects of the dura beneath the cervical vertebrae I, II and III, and was rather readily peeled off the dura. A lumbar tap, performed nine days after operation, demonstrated that there was no longer any block.

Pathologic Examination.—Dr. Paul Klemperer: "Sections of the material submitted show dense, almost hyaline, connective tissue, one fragment showing an area of calcification. The veins and capillaries are engorged with blood. There is perivascular infiltration with lymphocytes and occasional polymorphonuclear leukocytes and plasma cells extending here and there into the adjacent connective tissue. Connective tissue fragments showing chronic inflammation. No evidence of phlebitis."

Diagnosis.—At the onset, in the acute abscess cases, the pain in the back, the initiating symptom, will give no lead as to the actual condition. Such a pain, associated with a mild or even a high temperature, can be, of course, due to any one of a number of conditions. As the pain continues, however, with ever-increasing severity, a suspicion as to the possible underlying pathology will be aroused. If the history of antecedent infection is obtained, and the pain is as low as the lumbar region, associated with some tenderness over the muscles in that region, a perinephric abscess may be suspected, as it was in Case 4. With the advent of paresis, poliomyelitis will be thought of. In this condition, however, one does not find sensory changes. After the advent of the paralysis, a spinal cord tumor will be considered. The finding of xanthochromic fluid and block may further suggest this diagnosis. However, increased temperature, if present, the leukocytosis, and the rapidity of the progression of the motor signs speak against the usual spinal cord neoplasm. If, as is often found, the paraplegia is a flaccid one, we have additional evidence. While a similarly rapid progression, associated with a flaccid paraplegia, is sometimes seen in spinal cord tumors, they will usually be found to be the result of a metastasis. The age-group in most cases of acute epidural spinal abscess is against this possibility.

In the chronic granulomata a history of an overlying infection may suggest the pathology of the lesion, as it did in Case 7. While a history of a direct trauma would bring up the same question, in most instances the diagnosis of spinal cord tumor will be made and the pathology will be disclosed only at operation.

Treatment.—There is only one treatment for acute, epidural spinal abscess—prompt operation. A laminectomy, to provide adequate drainage of the infected focus, should be performed, and the wound left wide open. In most cases the removal of the arches from two or three vertebrae will be sufficient. In rare instances a more extensive procedure, or a second laminectomy in the lumbar region, may prove necessary. In Case 2, lumbar drainage was adequate in caring for a cervical lesion. In the chronic granulomata the indications and treatment are those of spinal cord tumor.

Prognosis.—As far as can be determined from reported cases, no instance of epidural spinal abscess has lived unless operated upon. The outcome of operation can be considered from two aspects; one, as to life; the other, as to return of function. If the sepsis continues actively, so that the intraspinal abscess is only a part of the picture, the prognosis is that of the sepsis. This

was surely the condition in Case 1 and probably in Case 5. Another possibility, also shown in Case 5, is the spread of the infection, even though it was considered adequately drained at the time of the primary operation. A third factor leading to a fatal issue is that found in all cases of complete transverse lesions of the cord. I refer to the respiratory and urinary tract infections and spreading decubitus.

Meningitis, as a complication, is relatively rare when the dorsal epidural space is involved. The dura offers a real barrier to the spread of the infection to the subarachnoid space. In the rare instances, where the lesion is anteriorly placed, meningitis seems to be more frequent.

Functional return will depend on the extent of the damage to the spinal cord before treatment is instituted. In the face of a flaccid paraplegia, such as was seen in Case 3, no improvement can be expected. If, fortunately, the diagnosis is made early, as in Case 4, the functional result will be perfect. In between these two extremes there are any number of gradations.

SUMMARY

The relationship of acute, metastatic epidural abscess and chronic granulomata of the epidural space is discussed.

Five cases of abscess and two of granuloma are recorded. Their symptomatology and diagnosis are discussed. The need of prompt recognition and adequate surgical treatment, especially in the abscess cases, is emphasized.

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TOXIC MYELOPATHY (SPINOCAINE) *

SOME CONTRAINDICATIONS TO SPINOCAINE ANESTHESIA

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NEUROLOGIC complications following spinal anesthesia have been reported frequently. It is the purpose of this communication to review some of the literature, report four cases, and consider the pathology of toxic myelopathy.

The use of spinal anesthesia has become widespread except in instances of severe myocardia disease, hypertension, marked hypotension, and psychoneuroses. The following exceptions to the employment of spinocaine should be added: Congenital anomalies in general, particularly those of the central nervous system, and diseases of that system; congenital anomalies and diseases of the circulatory system, such as tendency to, or presence of, varicosities, endarteritis or phlebitis; and congenital anomalies and diseases of the skin and epidermal appendages, such as pilonidal cyst (Case 2), with which spina bifida occulta is often associated. These exceptions are made to direct attention to conditions which are inherent and are early evident, those which may appear late, and those which may be early acquired. These include affections of neural structures, and disturbances of the circulation of those structures. A diminished vascular efficiency would not favor immediate, and possibly even delayed, restitution of function of a spinal cord bathed by toxic cocaine derivatives.

Stovaine[1] (amylococaine hydrochloride) injected into the subarachnoid space of dogs and apes causes degeneration of the roots and periphery of the cord, and retrograde changes in the anterior horn cells. The spinal anesthetics[2] commonly employed (nupercaine, spinocaine, gravocaine and seurocaine, which contain procaine as their chief constituent) have been shown to be both myelolytic and hemolytic. When injected into dogs they produce an aseptic meningeal reaction with an exudation of plasma cells and a proliferation of arachnoidal cells, which later results in a thickening of the meninges, disintegration of axones and degeneration of the peripheral portion of the cord. Somewhat similar changes have been demonstrated[3] in the spinal cords and nerve roots of patients dying following spinal anesthesia (procaine hydrochloride).

Following the subarachnoid injection of 5 per cent procaine hydrochloride into rabbits,[4] the reversible reaction was followed for 24 hours. At two hours

* Approved for publication by The Surgeon General, United States Public Health Service. Submitted for publication November 10, 1937.

there were chromatolysis and swelling of the cells, with scarcely any normal cells in the anterior horns. At six hours there was much improvement and at 24 hours the cells were normal again. Unfortunately this does not always occur, nor is it known why; except that the conditions mentioned above might be considered as predisposing to such complications.

In addition to the effects of the anesthetic, an error in technic might be a factor. When the spinal needle is inserted, it is important that further progress of the needle be arrested just after it has passed through the dura. Pushing the needle further may traumatize the closely matted nerves of the cauda equina and the vessels of these nerves. An admixture of blood may change the properties of the injected anesthetic and lead to a reactive fibrosis in the form of leptomeningeal adhesions. Still further progress of the needle will bring it to the anterior wall of the spinal canal which often contains a large emissary vein from the body of the vertebra. The impact of the needle against the bone, and the pain of which the patient complains, indicate that the needle has reached that point. A sharp shooting pain down one leg or a sudden flexion of that leg would indicate that one of the nerves of the cauda equina had been irritated. Conservatism might dictate that the mishaps mentioned be considered as contraindications to continuing with the spinocaine anesthesia.

As an anesthetic, spinal has about the same immediate mortality, and death rate from postoperative pneumonia, as has ether, but is superior to it in that it produces greater muscular relaxation and does not have the ill-effects which follow ether.

Foss and Schwalm[5] have reported 3,000 cases of spinal anesthesia (procaine hydrochloride) without a single neurologic complication. Others[6] have reported percentages of 0.01 (percaine mainly, as well as stovaine and spinocaine and others) to 0.5 (compilation of 2,074 cases in which spinocaine, neocaine and novocaine were used).[7] Almost any part of the central nervous system may be affected, with the involvement remaining permanent or causing a fatality. Hyslop[7] divided the neural complications into three types: (1) Local or neighborhood, such as lesions of the cauda equina; (2) distant focal, such as cranial nerve palsies; (3) general, such as aseptic meningitis or meningo-encephalitis.

Brock[8] reported seven cases with a pathologic study of one. Case 1 (procaine preparation) was an acute, benign, lymphocytic meningitis with a high spinal fluid sugar; Case 2 (nupercaine) a severe meningitis characterized by polynucleosis and disappearance of sugar from the spinal fluid; Case 3 (procaine preparation) an almost fatal polio-encephalitis with residua 19 months later; Case 4 (procaine preparation) a severe radiculitis involving the area of the groin, scrotum and testicles and appearing three weeks after the anesthetic; Case 5 (nupercaine) severe cauda equina neuritis 24 hours after a second spinal, the first one having been given 37 days previously; Case 6 (type of spinal anesthetic not stated) a cauda equina neuritis with mild cord involvement which in the next 29 months developed into a fatal transverse

myelitis and radiculitis. Immediately on injecting the spinal anesthetic the patient suffered such severe pain radiating down the legs that a general anesthesia had to be employed in order to complete the operation. Case 7 (nupercaine) developed a toxic myelopathy with the symptoms of spinal shock and a fatal issue in three months. Examination of the spinal cord in this case revealed extensive destruction of the myelin sheaths, axis cylinders and glia, mostly at the periphery of the cord and at the entrance zones of the posterior roots. The ganglion cells of the anterior and lateral horns were also slightly involved. Davison and Keschner,[9] in their study of toxic myelopathy (toxins from bodily infections), noted that the periphery of the cord, being closest to the toxic substance, was more involved than the central parts, and that there was a lack of glial response, which is consistent with a disease of short duration. Davison and Keschner[10, 11, 12, 13, 14] have clarified the problem of spinal cord disease and emphasized the extreme rarity of true myelitis of infectious origin. They preferred to call all other cord affections myelopathies due to toxins or circulatory interference.

It was Brock's[8] belief that all the neural complications could not be explained on the chemotoxic effect of cocaine derivatives, but assumed that there must be a tissue sensitivity. In Case 4 there was a long interval between the anesthesia and the onset of symptoms, and in Case 6 a cauda equina neuritis and a mild cord involvement progressed to a fatal transverse myelitis. "One is led to assume that an original chemotoxic effect permitted other factors (virus?) to operate on a neural tissue devitalized by the anesthetic." A polyneucleosis with a disappearance of sugar in one spinal fluid and a lymphocytosis in the other strongly suggests the presence of a virus in one of them.

CASE REPORTS

Case 1.—A male, age 21, was admitted to the hospital July 4, 1932. A pilonidal cyst was removed without sequelae; 1.5 cc. of spinocaine was used. A recurrence was excised, in July, 1934, under spinocaine anesthesia, 1.5 cc. being used. In January, 1935, a second recurrence was removed under 1.5 cc. of spinocaine. The diagnosis was infected dermoid cyst containing a nest of hair. Varicose veins, which had appeared in both lower limbs since his second admission, were successfully injected. In April, 1935, a third recurrence, containing sebum and hair, was excised under 1.5 cc. of spinocaine. The cyst never extended deeper than the fascia over the coccyx.

Immediately following the last operation, he complained of numbness of the right lower quadrant of the abdomen, perineum, penis, the right buttock, thigh and the whole right leg; flaccid paralysis of the right leg; urinary retention and bowel incontinence. At first he required catheterization but later could evacuate the bladder by suprapubic pressure. Bowel incontinence or constipation remained. He had no control over enemata. On discharge, two and one-half months after the last operation, his bowel and bladder control had not improved. His leg, however, had begun to recover function, though it was still numb and stiff.

He had his fifth admission October 13, 1936, because of bowel and bladder difficulty. It had required five months before he could walk upstairs and the same period before sufficient anal sphincteric tone developed to prevent fecal incontinence. It took him 30 to 45 minutes to expel a two quart enema. In October, 1935, his older brother, age 29, had a pilonidal cyst successfully removed under ether anesthesia.

Physical Examination.—Showed well healed wound at site of pilonidal cyst removal; right testicle atrophic; no sensation to firm pressure or rubbing in any part of the rectum reached by the inserted finger; mucosa above internal sphincter redundant and relaxed; moderate mucosal prolapse on straining in the squatting position; a few small external rectal tags; internal sphincter tone fair; external sphincter tone poor. Over the left lumbar area, arranged like the petals of a sunflower, were café-au-lait spots covering an area the size of a man's hand. The old, rather prominent injected varicosities could be seen and felt on the left knee and the right calf.

Neurologic Examination.—Patient right-handed; walked slightly favoring the right leg, on which balancing was fair as compared to the left; gluteal reflex fair on the left, poor on the right; absent right knee jerk, ankle jerk and semitendinosus reflex; slight paresis of all flexors and extensors in the right leg as compared to the left, with tonus and mass of the right buttock much diminished; anesthesia, thermanesthesia and analgesia from the third to the fifth sacral segments on the right. Cranial nerves negative.

Laboratory Data.—Urine negative. Blood and spinal fluid Wassermann negative. Spinal fluid and manometric readings normal. Roentgenologic examination of the lumbosacral spine showed no evidence of any abnormality of the spine. The right sacro-iliac joint showed moderately increased density due to a mild osteo-arthritis. There was no evidence of spina bifida occulta.

Cystometrogram.—Revealed a bladder of normal capacity but slightly increased irritability, a tendency to develop desire to void, and pain at low normal pressure and capacity, with very rapid response to pilocarpine causing early desire to void and pain mainly on volitional bladder evacuation. The bladder had been previously infected.

Subsequent Course.—Various parasympathicomimetic drugs were used for therapeutic and diagnostic reasons as well as combinations of these with laxatives and pituitrin. The most favorable combination consisted of 4 cc. of fluid extract of cascara sagrada and 8 cc. of mineral oil at 9:00 P.M., and after breakfast, at 8:00 A.M., ½ cc. of surgical pituitrin subcutaneously. Within five minutes he had a complete and satisfactory bowel and bladder evacuation. At 10:00 A.M., and 3:00 A.M., he took orally 1/16 gr. of pilocarpine and had two complete bladder evacuations.

Second Cystometrogram.—February 3, 1937: Revealed a less irritable bladder, with desire to void and pain at the average normal pressures, and an ability to develop intracystic pressure on straining to void with help of the abdominal muscles, almost twice what it had been before. This indicated a definite increase in control over the voluntary muscle and an even more marked and rapid response to pilocarpine greater than normal.

Neurologic Examination.—February 4, 1937: Still gets cramps in the posterior muscle group of the right leg on exertion. Absent right knee jerk and semitendinosus reflex with return of ankle jerk. Left upper extremity reflexes more active than lower, with left abdominals more active than the right. Both cremasterics absent. Right buttock still flabbier than the left but firmer than previously. The weakness in the right leg was limited to flexion at the knee. Slight hypalgesia in the third and fourth sacral segments with a patch in the fourth lumbar segment. Much more and diffuse pressure sensation in the lower bowel except in the midline posteriorly under the operative scar. Mucosa not as redundant as previously. *Clinical Diagnosis.*—Toxic myelopathy (spinocaine).

COMMENT.—The recurrence of a pilonidal cyst is not uncommon. The successful administration of spinocaine anesthesia three times would hardly seem to raise a question about a fourth except that recurrently subjecting the spinal cord to a toxic substance might merit consideration, especially when the fourth was relatively soon after the third, namely, four months. It is known, however, that procaine hydrochloride spinal anesthesia has been administered five times in 38 hours,[15] and spinocaine 14 times in 17 months[16]

without injuring the spinal cord. The development of varicose veins between the second and third admissions and the finding for the first time of hair in the pilonidal cyst indicated the development of latent anomalies, one quite close to the end of the spinal cord and both possibly reflected in the coverings or substance of that structure. The finding of hair and sebum in the cyst the fourth time further affirms the progressive development of ectodermal dysplasias. Varicosities may be due to an inherent defect in the vessel walls and when they are associated with varicosities of the spinal cord, the vascular efficiency of that structure is impaired.

The café-au-lait spot had not changed but had always been present as an evidence of another ectodermal dysplasia. The occurrence of a pilonidal cyst in an older brother is also of interest. However, it indicates that an anomaly which may be familial, though not hereditary in this case, appears earlier and is more developed in those born later. This patient, ten years younger than his older brother, developed a pilonidal cyst at age 18 while it did not appear until the latter was age 29.

Whether the osteo-arthritis of the right sacro-iliac joint was present before the toxic myelopathy cannot be said, but it is unlikely. The atrophic testicle was not. It is possible that both these conditions are the result of a disease of the trophic centers for these structures in the spinal cord or at least for testicular innervation. The inordinate bladder response to pilocarpine without a comparable general reaction is suggestive. The relaxation of the muscles and tendons about the right sacro-iliac joint could have exaggerated the normal stresses and strains to traumatic importance.

Case 2.—A male, age 39, was admitted to the hospital September 25, 1936, with the diagnosis of postoperative appendiceal hernia and right indirect inguinal hernia. On January 1, 1936, and again two months later, he had been operated upon for a ruptured appendix. He had worked for two months in the interim.

Physical Examination on admission was negative, except that he was a very tense, apprehensive, overconscientious, and a somewhat suspicious individual.

Laboratory Data.—Urine, blood Wassermann and Kahn reactions negative.

Operative Procedure.—September 28, 1936: Both herniae were repaired. Three cubic centimeters of spinocaine were employed. Just before operation the patient's blood pressure was 178/78. After operation, as on admission, it was 120/80. The next morning the patient could void but complained of excruciating shooting pains in the left hip and calf and to a less extent in the right calf. On the third day he felt better but had tingling sensations in both legs. On the fifth day he insisted his legs felt paralyzed although he seemed to move them normally. On the fifteenth day he had developed pain and tenderness in the left heel. On the twenty-second day he was up and about but complained of pain in the perineum, drawing sensation in the left groin, some disturbance in anal sphincteric control, and at times terrific pain deep under the operative wound, radiating through to the back. Repeated urine examinations were negative.

Neurologic Examination.—October 26, 1936, 28 days postoperative: The patient stated that if he walked upstairs too frequently he developed a spasm in the perineum. No penile erection had been experienced since operation, and there was no spontaneous desire to void or defecate. He had "no control about emptying the bowel," and noted that if he "took a deep breath" it would evacuate spontaneously.

The patient walked very carefully, with his legs apart as if straddling a painful perineum of which he actually complained. Balancing poor on the left foot; tremor of the extended fingers, right more than left, which the patient stated had been present before operation; deep tendon reflexes were increased with the left biceps greater than the right, left knee jerk greater than the right, but right ankle jerk greater than the left; hypalgesia and thermhypesthesia from the third to the fifth sacral segments bilaterally. The external anal sphincter was weak and the internal sphincter gripped the finger poorly. As far as the rectal examining finger could reach there was no sensation of pain and only on the left lateral wall was there a slight feeling of pressure to very firm palpitation by the inserted finger.

Cranial Nerves.—Right pupil greater than left, with both reacting well to light and accommodation; vision 20/15 in both eyes; both occular fundi were quite hyperemic, with all the vessels engorged; optic disk margin on the left was indistinct, suggesting pseudoneuritis. The smaller arteries showed diffuse and irregular narrowing.

Cystometrogram.—October 28, 1936: Normal bladder oscillations; first desire to void felt at 350 cc. with pressure of 120 Mm. of water; pain felt at 600 cc. with pressure of 270 Mm.; with straining could reach only 270 Mm.; following the injection of pilocarpine grains ⅛, with the bladder containing 350 cc., after 30 minutes, the pressure was only 180 Mm.

Spinal Puncture.—November 3, 1936: Fluid clear and colorless, no increase of cells or globulin. Initial pressure was 160 Mm. of water, and the manometric readings were normal. The patient insisted that many of his symptoms disappeared following this procedure and subsequently urged when they recurred that it be repeated.

Using parasympathicomimetic drugs, the patient's bladder and bowel control improved markedly, and on December 18, 1936, a cystometrogram revealed normal findings.

Neurologic Examination.—December 18, 1936: The patient had been able to walk four or five miles daily. Deep reflexes in left upper extremities were increased and right ankle jerk was greater than left; normal plantar responses. Slight hypalgesia over the third and fourth sacral segments on the right, and over the upper end of the third sacral segment on the left.

The patient's tenseness and anxiety had become less, but his hypochondriacal preoccupation, with many bizarre variations of his initial complaints, became marked. In spite of every reassurance that he had recovered, he refused to believe this, and had to be discharged against his wishes January 4, 1937. *Clinical Impression.*—Toxic myelopathy (spinocaine), and cauda equina neuropathy, psychasthenia.

COMMENT.—A very neurotic male, age 39, with premature senility, had, after prolonged illness which had an additional unfavorable effect on his already hypochondriacal attitude, a repair of two herniae under spinocaine anesthesia. Subsequent to this he immediately complained of pain down his right leg and developed signs and symptoms of a cauda equina neuropathy, from which he recovered almost entirely as shown by neurologic examination and cystometrograms. However, his mental attitude became definitely worse. It would seem that because of his neurotic make-up, premature graying of his hair and early cerebral vascular changes, he was a poor risk for the administration of spinocaine anesthesia. The poor recovery he made from the toxic effects of the drug, and the mental reaction that he exhibited, once this had occurred, seemed to substantiate this.

The inadvisability of administering spinocaine anesthesia to a patient who is very tense, anxious and agitated before an operation, as well as fearful of

it, must be emphasized. Three cases of postoperative atelectasis and pneumonia following spinocaine anesthesia have been observed. Panic on the part of these patients seemed to be a very important factor. They hold themselves rigidly, not only because of mental perturbation but also from fear of pain. Their respirations are extremely shallow, resulting in a minimal movement of the diaphragm and little aeration of the lower lobes of the lungs, with consequent poor blood oxygenation, which predisposes to atelectasis. This occurs in cases where no permanent injury remains to the spinal cord. These individuals also exhibit a predilection for hysterical conversion symptoms of a motor or sensory nature. Affections of bowel, bladder and potentia also occur. All of these are most disturbing not only medically but also from a forensic point of view.

Case 3.—A male, age 60, was admitted to the hospital December 2, 1936, because of external and internal hemorrhoids. For 25 years he had been "extremely nervous."

Physical Examination.—A well developed, well nourished, white haired, very tense male. Blood pressure 120/80. Peripheral vessels moderately thickened, and tortuous. Dorsalis pedis pulses present. Internal and external hemorrhoids with dilation and tortuousity of hemorrhoidal veins.

Laboratory Data.—Urine and blood Wassermann negative. Spinal fluid and manometric readings normal.

Operative Procedure.—December 4, 1936: The hemorrhoids were injected with 8 cc. of 5 per cent phenol in oil, under 60 mg. of spinocaine anesthesia. Immediately after operation he could move his legs but the left one had a "restless feeling." The urinary stream was weak and the stools thin and unformed. On the second day the right arm began to shake, and he had a shooting pain behind the right ear on turning to the left; the pain in his right index finger was so severe he could not close his fist.

Neurologic Examination.—December 12, 1936: The right arm hung limply at the side; on walking forward with his eyes closed, he wandered ataxically to the left; ataxic intention tremor bilaterally on finger to nose test; very slow in performing fine finger movements with the right hand; left dysdiadokokinesis; gross rest-tremor of the right upper arm which extended to the hand on attention, intention and excitement; right hyper-reflexia with all deep reflexes being generally increased; abdominal reflexes diminished, but the cremasteric reflexes very active; right grip weak, left lower leg deformed and somewhat atrophied due to an old fracture but with good power; vibratory sensation diminished in all toes, more so on the left.

Cranial Nerves.—Both pupils of almost pin point size, the left being slightly greater than the right. Both reacted promptly, though to a very limited degree, to light and accommodation. Smaller retinal arteries showed slight narrowing.

Following a spinal puncture, the tremor of the right upper arm disappeared temporarily.

Cystoscopic Examination.—December 23, 1936: Right, left and middle lobes of prostate markedly enlarged. Median bar markedly hypertrophied. Marked trabeculation of the bladder wall. Contracture of the bladder. Re-examination, February 23, 1937, revealed that normal bowel and bladder function had been restored. The right arm still swung slightly less than the left; moderate fine tremor of the extended fingers bilaterally, right more than left; reflexes all equally hyperactive; motor power good throughout except for old left leg weakness; no sensory disturbances; pupils unchanged. He was discharged to duty March 4, 1937.

Clinical Diagnosis.—Toxic myelopathy and radiculopathy (spinocaine); generalized arteriosclerosis; psychasthenia.

COMMENT.—The long history of nervousness, the presence of peripheral, cerebral and very likely spinal cord vascular sclerosis, varicosities of hemorrhoidal veins and pupillary anomalies suggesting central nervous system involvement, seemed to have made this patient a poor candidate for spinocaine anesthesia. He developed signs and symptoms suggesting involvement of the spinal cord and radicular nerves as well as paresis and tremors of a functional nature. His recovery was fairly rapid and almost complete although there were still some slight residua on discharge.

Case 4.—A male, age 28, was admitted to the hospital September 25, 1932, because of right lower quadrant pain which had started 12 hours previously.

He was much wrought up, feeling that due to general mismanagement his life had been endangered. He became even more convinced of this upon the unhappy progress of his case.

Physical Examination.—Well developed, tall, athletic male who appeared acutely ill. Blood pressure 110/68. Heart and lungs negative. Righ lower quadrant tenderness and spasm.

Laboratory Data.—White blood count 12,800, P-78, L-14, M-8.

Operative Procedures.—An appendicectomy was performed the day after admission. During the spinocaine anesthesia (2.4 cc.), there was much respiratory embarrassment and irregularity of the pulse. Immediately after the operation the patient complained of pain and weakness in the left leg and pain in the right ankle. He also began to vomit. This continued, in addition to having attacks of tachycardia with a pulse of 180 and no comparable temperature rise. On September 30, 1932, under gas-ether anesthesia, an exploratory celiotomy and an entero-enterostomy were performed. Generalized peritonitis and a constriction at the ileocecal junction were noted. Following a stormy convalescence his intra-abdominal condition improved.

Neurologic Examination.—November 4, 1932: Hypesthesia of the entire left leg except for the area between the toes and the inner side of the arch. This was felt to be of a functional nature. He was discharged, improved, November 7, 1932.

On December 2, 1932, he was readmitted because of stiffness of the tendons and aching pains in the left leg, particularly of the ankle which became swollen on exercise. At times he could not walk because of this discomfort.

Neurologic Examination.—December 8, 1932: On Laségue maneuver the patient complained of pain in the popliteal space. The circumference of the left calf was 1 cm. less than the right. Some urinary frequency during the day but no incontinence. Hypalgesia in area on anterior aspect of the thigh corresponding roughly to the intermediate cutaneous and medial cutaneous branches of the femoral nerve, though not of as great extent. It was felt that the spinocaine anesthesia was not the cause of these findings. Roentgenologic examination, December 10, 1932, revealed only slight soft tissue swelling in the posterior of the right ankle joint due to a mild synovitis.

He also complained of recurring violent abdominal cramps. Barium studies revealed the hepatic flexure to be slightly displaced to the left on account of a large liver. The transverse colon showed a spastic state, with the midtransverse colon constantly located in the right lower quadrant, suggesting adhesions.

Third Operation.—December 28, 1932: Under spinocaine anesthesia (2.2 cc.), the adhesions causing the obstruction were severed. The entero-enterostomy was functioning. The patient again had a stormy convalescence, and developed a right, nonspecific epididymitis and orchitis, and attacks of tachycardia of sudden onset and cessation, reaching at times approximately 200 systoles per minute. Electrocardiogram in the free interval was negative. He was discharged, improved, February 1, 1933. During the next four years he had five hospital admissions for symptoms relating to the sequelae of the spinal anesthesia.

At the time of his eighth admission (March 17, 1937, to May 10, 1937), he had developed, in addition to pain in both knees and ankles, pain in the left shoulder, elbow and wrist.

Three weeks after admission he was transferred to the Neurogolic Section where he was observed for two weeks. He had remissions and exacerbations without apparent cause. The ache was deep in the joints, not in the bone or surrounding tissues, which was not aggravated by motion or pressure but was made worse by effort and fatigue so that he became "wobbly." He was irritable and dissatisfied.

Neurologic Examination.—April 15, 1937: Gait was normal; on Romberg he swayed mostly to the left and backward (he felt he was turning counterclockwise and to the left); when eyes were closed and extended arms were brought to horizontal, the body and arms turned to the left. Balancing on each foot was fair, poorer on the left foot; pass points to the right with the left hand. Area of hypesthesia ("feels like roughness and itching you want to scratch"), hypalgesia ("like burning") and hypthermesthesia in the second and third lumbar segments on the anterior aspect of the left thigh. Calves were of equal size and the left thigh 1 cm. greater than the right (ref. examination December, 1932, at which time the left calf was 1 cm. less than the right).

Psychotherapy was begun with considerable enthusiasm on the part of the patient. Since the operation, in 1932, he had had marked insomnia, restlessness, easy fatigue, constipation and increasing disinterest in his work. He had married happily, December, 1936. Since childhood he had had nightmares. A review of his life history and attitudes revealed the origin of some of his character traits to him. He always had a feeling of inferiority and felt that no one was interested in him. With this attitude he abandoned himself to all manner of escapades, always submitting to punishment without question when caught.

Even with the most superficial explanations of his problems he greatly improved, and all the above symptoms disappeared. On the day of his discharge back to duty, the only neurologic signs were sensory disturbances in the second and third lumbar segments on the left thigh, characterized by hypesthesia, with a feeling of dulness, hypalgesia, with a burning quality, and hypthermesthesia. *Clinical Diagnosis.*—Toxic cauda equina neuropathy (spinocaine); traumatic neurosis (improved).

COMMENTS.—An athletic, previously healthy male had an appendicectomy, performed under spinocaine anesthesia. Following this a whole train of unhappy symptoms developed and resulted in eight hospitalizations. His upper respiratory infection favored the emloyment of such an anesthetic, but his extremely wrought-up mental condition should have precluded its use. How much his mental state played a part in initiating his vomiting attacks and perpetuating an already confused situation, ending in two additional operations, can only be problematic.

In reviewing his case with him, he constantly emphasized what he believed to be gross mismanagement as the causative factor. He had developed signs and symptoms of a toxic neuropathy affecting the cauda equina, peritonitis, intestinal obstruction, polyarthritis and traumatic neurosis in addition to his own character neurosis.

The motor as well as the sensory portions of the nerves were affected as indicated by the increase in size of the left thigh and calf in 1937, as compared with the measurements in 1932. It is possible that recovery might have been retarded by the second spinocaine anesthesia and the perpetuation of the dysesthesiae[17] which were so distressing, favored. The importance of the

patient's mental attitude in exaggerating symptoms which had a real organic basis and developing others as a functional elaboration must be mentioned. That this was the case was substantiated by the change in the picture following psychotherapy.

SUMMARY

The literature on neural complications following spinocaine and other forms of spinal anesthesia is reviewed to emphasize their frequency and unpredictability.

In addition to excluding patients having severe myocardial damage, hypertension or marked hypotension, other exceptions to spinocaine have been added. These are congenital anomalies in general, particularly those of the central nervous system and diseases of that system; congenital anomalies and diseases of the circulatory system, such as tendency to, or presence of, varicosities, endarteritis or phlebitis; and congenital anomalies and diseases of the skin and epidermal appendages, indicating possible disease of the central nervous system, such as pilonidal cyst. The importance of severe neurotic traits as a contraindication to the employment of spinocaine anesthesia was emphasized.

The first case reported was that of a young male who, following his fourth spinocaine anesthesia, developed signs of a severe spinal cord and cauda equina neuropathy from which he never fully recovered. The recurring pilonidal cyst, developing varicosities in the lower extremities and café-au-lait spots, were suggested as possible contraindications to repeated spinocaine anesthesia.

The second case was that of a male, age 39, with presenility and severe hypochondriasis, who developed signs of a transient cauda equina neuropathy from which he recovered, but in whom a residual, severe psychesthenia developed, which was built up about the symptoms resulting from the original neural lesion.

The third case was that of an adult male with generalized arteriosclerosis, varicosities of hemorrhoidal veins, pupillary pathology and a long history of "nervousness." Following spinocaine anesthesia he developed signs and symptoms of an organic and functional nature indicating diffuse spinal cord and radicular nerve pathology, from which, however, he made a gradual recovery but of which there were still some residua.

The fourth case was that of a very healthy, athletic male, age 28, whose appendix was removed under spinocaine anesthesia, during a period in which the patient was in a much wrought-up mental condition. He developed signs and symptoms of a cauda equina neuropathy, an intestinal obstruction, which required two subsequent operations, and a traumatic neurosis resulting in eight subsequent hospitalizations during the following five years. The atrophy of the left leg had disappeared but the dysesthesiae have remained. Much improvement in all his symptoms followed psychotherapy.

It is suggested that if the above criteria for the selection of cases are considered, the number of complications following spinocaine anesthesia would be diminished.

Addendum.—Since this report was submitted for publication, a fifth case has been observed four years after spinocaine anesthesia. There was evidence of a severe myeloradiculopathy of the lumbar spinal cord and nerves. Marked vasomotor instability was noted, the signs and symptoms of which were known to have been present even before the spinal anesthetic was administered. Such vascular disturbances have been suggested as contraindications.

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THE EFFECT OF BREATHING 95 PER CENT OXYGEN UPON THE INTRALUMINAL PRESSURE OCCASIONED BY GASEOUS DISTENTION OF THE OBSTRUCTED SMALL INTESTINE

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IN A NUMBER of recent communications the value of breathing 95 per cent oxygen for the relief of intractable gaseous distention of the intestine has been set forth on the basis of clinical and experimental data.[1, 2, 3, 4] The laboratory studies which provided the basis for clinical application of the method demonstrated the capacity of 95 per cent oxygen to deflate a closed loop of small intestine distended with nitrogen, which, in man, forms the major constituent of the distending gases. The mechanism by which the oxygen accomplishes this result consists in the exclusion of nitrogen from the inspired air. According to the law of gases, the diffusion of any gas through a semipermeable membrane is proportional to the difference between its partial pressure upon the two sides of the membrane. Inhalation of pure oxygen necessarily reduces the pressure of nitrogen in the lungs toward zero, so that nitrogen in the blood diffuses into the expired air; and by the same mechanism the resulting reduced partial pressure of nitrogen in the blood allows this gas to diffuse more rapidly from any body cavity or tissue space into the blood, whence it is expelled through the lungs. *The oxygen per se has no direct effect on the diffusion process. Its virtue lies only in the fact that, when properly used, it is a convenient respirable gas which prevents nitrogen from being inhaled.*

The experimental studies clearly demonstrated that: By causing an animal to breathe pure oxygen instead of air, the volume of nitrogen in a closed loop of small intestine distended with this gas can be reduced in 24 hours to about 40 per cent of its original volume. This is in contrast to an average variation of only 10 per cent of the original gas volume when the animal breathes room air for the same period of time. The pathologic changes in ileus are primarily referable to the effect of increased intraluminal tension, rather than gas volume. We propose, therefore, in this paper to supplement the observations already published[1, 2, 3, 4] on gas volume changes with experimental data on comparative intra-intestinal pressure changes in the bowel distended with air or nitrogen: (1) In animals breathing room air; and (2) in animals breathing pure oxygen.

Method.—The abdomen of cats, starved for 24 hours, was opened under intraperitoneal nembutal anesthesia and the pylorus ligated. A large glass

Submitted for publication March 15, 1938.

cannula was securely tied into the lowest portion of the ileum and an occluding ligature placed immediately distal to the cannula. The abdominal wall was closed around the other end of the cannula, which was connected by a T-tube to a mercury manometer and to a Perusse pressure bottle. The intestine was then inflated with atmospheric air by increasing increments of pressure until a final pressure of 800 Mm. of water was established at the end of five hours. This pressure was maintained for one hour, following which the Perusse bottle was clamped off. The intraluminal pressure was recorded on a slowly moving kymograph until the animal died or was sacrificed. One group of 12 cats breathed atmospheric air, another group of 14 breathed pure oxygen from the time the Perusse bottle was clamped off until the experiment terminated. Intra-intestinal pressure tracings, data on the bowel and peritoneal fluid content, bowel weight, length, and gross appearance were compared in these two groups. A third group of four cats, in which the intestine was similarly treated except that no air was injected into the intestine, served as controls for the data on bowel weight and length, intra-intestinal and intraperitoneal fluid content. All of the animals were kept under intraperitoneal nembutal anesthesia for the duration of the experiments.

The selection of a final intra-intestinal pressure of 800 Mm. of water (60 Mm. Hg.) as a basis for a comparison of the deflating process in an animal breathing air as against one breathing oxygen, is somewhat arbitrary. It was chosen because it represents a level of intraluminal tension which, though considerably in excess of that which is ordinarily observed clinically,* may, if sustained for a number of hours, be considered sufficiently high to cause local and constitutional effects and at the same time to serve as an adequate test of the capacity of oxygen inhalations to decompress a severely distended intestine. The establishment of this degree of pressure was purposefully effected in stages over a period of five hours, rather than abruptly, in order to simulate to some degree the clinical condition in which the tension accumulates over a period of hours or days rather than minutes.

Results.—When the small intestine of the cat, ligated at the pylorus and ileocecal valve, is gradually distended with air to a pressure of 800 Mm. of water in accordance with the technic described above, the subsequent course of events, in the average instance in an animal breathing air, is as follows: There is a slow and steady decline in the intraluminal pressure for a few hours to an average minimum of 433 Mm. of water, with extremes varying from 130 to 774 Mm. of water. The physiologic processes operating to reduce

* The intra-enteric pressure in mechanical obstruction of the small intestine in man has been observed to vary between 40 and 140 Mm. of water pressure, with increases as high as 300 Mm. during peristaltic activity.[5] Such determinations of the intra-enteric pressure, unless made under constant volumetric conditions, may be considered lower than the actual values. We have observed in the cat a drop from 364 Mm. of water pressure to 277 Mm. upon the withdrawal of 2.5 per cent of the total gas volume in the bowel, and from 277 to 91 Mm. when 7 per cent was withdrawn. Hence a leak around the needle injected into the bowel, or an appreciable displacement of gas into the manometric system, will register a pressure below its true value.

the initial pressure may be threefold: (1) The nitrogen diffuses slowly into the blood stream (and possibly into the peritoneal cavity) because its tension in the intestine exceeds that in the blood stream and the surrounding tissues. (2) The oxygen fraction of the injected air is absorbed rather rapidly. The rate at which this occurs in these distended animals, however, is slower than is to be expected normally, in proportion to the extent to which the blood supply in the intestinal wall is reduced by the increased intraluminal tension. (3) Relaxation of muscle tonus or paralytic dilatation from prolonged overstretching of the bowel wall may reduce the tension.

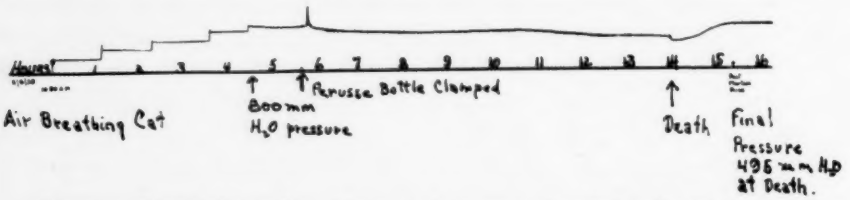


CHART 1.—Kymographic tracing of intra-enteric pressure of small intestine ligated at pylorus and ileocecal valve and inflated through a Perusse bottle with air in increasing increments each hour for five hours up to a maximum of 800 Mm. of water. At the end of the sixth hour the Perusse bottle was clamped off and the animal was allowed to deflate spontaneously. Breathing room air. Death occurred eight hours later with final pressure of 495 Mm. of water.

Once the minimum pressure is attained it usually remains unchanged until death of the animal occurs (Chart 1). In four of the 12 cats breathing air, however, a subsequent rise in pressure occurred (Chart 2), which in three cases exceeded the initial level of 800 Mm. of water. The average survival time in those cats not showing this secondary rise was 11.7 hours. The average survival time in those which did show such a secondary rise was only 5.25 hours. In one such animal, the pressure fell from 800 to 700 Mm. of water during the first hour, but in the following one and one-half hours it rose to 1,065 Mm. of water and the cat expired, a survival time of only two and one-half hours. Another showed no drop from the initial level, the pressure rising steadily from 800 to 1,690 Mm. of water in four hours, at which time death occurred.

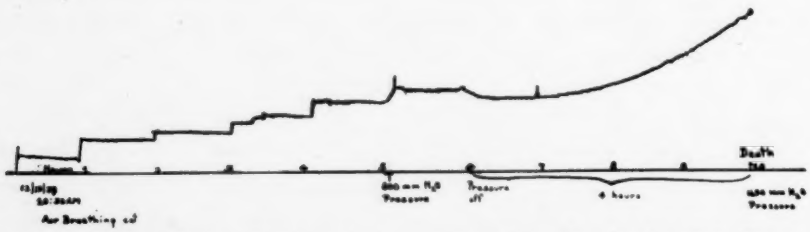


CHART 2.—Same as Chart 1. Secondary rise in pressure one hour after clamping off the Perusse bottle, and death four hours after. Breathing room air.

We have no data to explain the mechanism underlying this secondary rise in pressure. Increase in muscle tone or the formation of gases in the bowel by bacterial action may account for it. It is clear from our autopsy data that it cannot be accounted for on the basis of increased fluid in the bowel lumen (Table I). Whatever the mechanism, it is important to note that when such

a secondary rise is superimposed on a long sustained high intra-intestinal pressure, death rapidly results. If such a phenomenon exists in man, its clinical importance in hastening death from overdistention is sufficiently clear and justifies unremitting effort to reduce a gaseous distention of a severe grade.

TABLE I

DISTENDED ANIMALS BREATHING ROOM AIR

Small intestine ligated at pylorus and ileocecal valve. Cannula inserted into terminal ileum. Bowel inflated with air over period of six hours, in increasing increments, to a level of 800 Mm. of water pressure by means of Perusse bottle (in all cases except Exper. 8 in which nitrogen was injected by means of a syringe to 1,015 Mm. of water).

Experiment Number	Total Survival Time in Hours	Minimum Pressure in Millimeters of Water	Pressure at Time of Death in Millimeters of Water	Peritoneal Fluid in Cubic Centimeters	Fluid Content of Bowel in Cubic Centimeters	Ratio of Bowel Weight to Body Weight in Per Cent
1	29*	130	169	17	10	2.29
2	17	260	260	33	35	2.91
3	20	325	455	21	10	2.99
4	19	390	400	33	45	2.46
5	12½*	390	390	25	2	3.12
6	13	440	440	46		2.79
7	14	494	494	43	10	1.59
8	11	728	728	59	2	2.84
9	11	494	650	59	22	2.44
10	16	364	950	27	10	2.42
11	8½	700	1,065	21	2	2.68
12	10	774	1,690	36	15	2.16

* Sacrificed at time indicated.

That reduction of the distention will prolong the life of the animal is to be expected. We wish now to present evidence that the inhalation of 95 per cent oxygen accomplishes this result by effecting a steady decline in the pressure level of the intestine distended by atmospheric air or nitrogen (Table II). Fourteen animals, prepared in exactly the same fashion as the

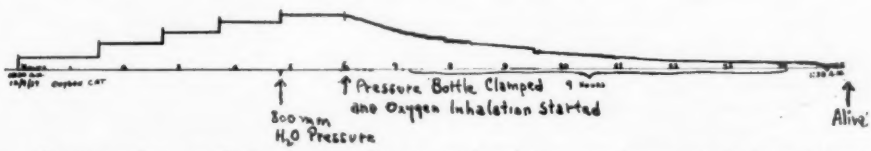


CHART 3.—Same as Chart 1, except that the cat breathed oxygen instead of air from the time the Perusse bottle was clamped off until the end of the experiment. Animal alive, deflated and in good condition nine and one-half hours later.

distended control group, were caused to breathe pure oxygen following the gradual establishment of an intraluminal pressure of 800 Mm. of water by distention with atmospheric air or nitrogen. The course of events described above as occurring in cats breathing air is in definite contrast to that occurring

TABLE II

DISTENDED ANIMALS BREATHING PURE OXYGEN

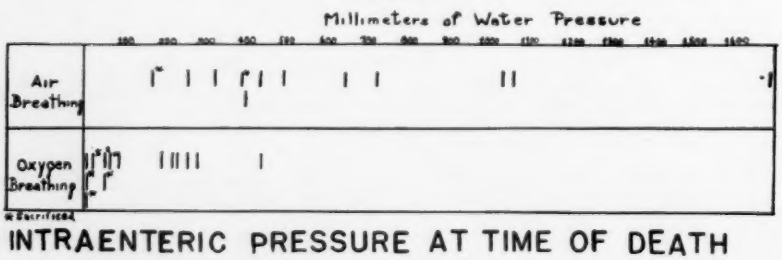
Small intestine ligated at pylorus and ileocecal valve. Cannula inserted into terminal ileum. Bowel inflated with air over period of six hours, in increasing increments, to a level of 800 Mm. of water pressure by means of Perusse bottle (in all cases except Expers. 3, 11 and 13 in which nitrogen was injected by means of a syringe to 600, 1,430 and 1,220 Mm. of water pressure, respectively).

Experiment Number	Total Survival Time in Hours	Pressure at Time of Death in Millimeters of Water	Peritoneal Fluid in Cubic Centimeters	Fluid Content of Bowel in Cubic Centimeters	Ratio of Bowel Weight to Body Weight in Per Cent
1	32*	0	24	5	3.37
2	19	0	25	0	3.01
3	18*	0	20	—	2.86
4	22*	19	8	21	1.7
5	26*	52			
6	29*	52	31	5	2.07
7	24*	65	33	0	2.49
8	27	78	23	15	1.78
9	17	195	28	10	2.14
10	19	225	29	10	2.77
11	18	234	38	10	1.59
12	14	260	19	23	2.56
13	17	286	30	15	2.62
14	17	442	46	10	3.11

* Sacrificed at time indicated.

in those breathing oxygen. In the former, the intraluminal pressure, after an initial decline, leveled off to an average minimum of 433 Mm. of water, while in the latter the pressure continued to fall until it reached a normal or nearly normal level (20 to 40 Mm. of water[5]) in eight of the 14 animals (Charts 3 and 4). The average intra-enteric pressure reached was 136 Mm. of water with extremes varying from zero in three instances to one with an

CHART 4

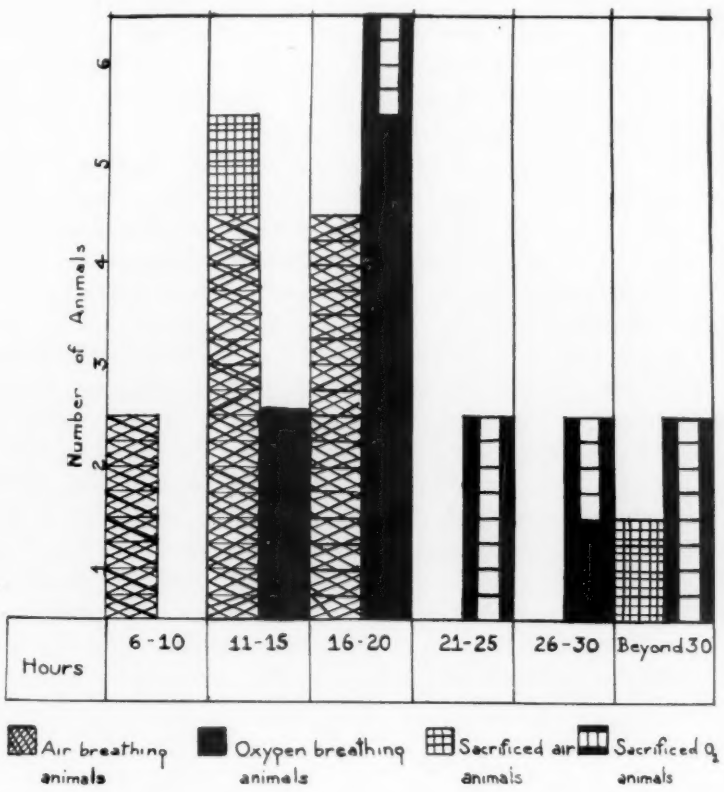


INTRAENTERIC PRESSURE AT TIME OF DEATH

exceptionally high level of 442 Mm. of water. The secondary rise in pressure observed in four of the air breathing animals did not occur in any of those breathing oxygen.

Concomitant with the greater reduction in intra-enteric pressure there was a notable prolongation of the survival time (Chart 5). Six animals died with an average survival time of 18.8 hours following the establishment of the initial pressure level of 800 Mm. of water, as against an average survival time of 8.5 hours for those animals breathing air. Six others breathing oxygen were sacrificed while still in good condition after an average survival of 25 hours. Two cats which were distended with nitrogen up to an initial level of 1,220 and 1,430 Mm. of water pressure lived 17 and 18 hours respectively.

CHART 5



SURVIVAL TIME

The initial drop in pressure during the first one to three hours was of much the same order of magnitude in both oxygen and air breathing animals (compare Charts 1 and 3), although two of the latter did not show even this preliminary drop. One might expect the oxygen breathing animals to show a more precipitous fall in pressure during this early period than those breathing air. Its failure to occur is explained by the fact that a latent interval of three to four hours, during which the blood stream becomes desaturated of the nitrogen dissolved in it, is necessary before nitrogen in any quantity begins

to diffuse from the bowel lumen into the blood stream with resulting decompression.[9]

The peritoneal fluid recovered at autopsy from the animals breathing air averaged 33.3 cc., while that recovered from those breathing oxygen averaged 27.2 cc. In a corresponding group of four animals, similarly treated but not distended, the peritoneal fluid averaged 6.5 cc., which was chiefly blood incidental to operative manipulation. The distended animals, therefore, showed an average excess of 24 cc. of peritoneal fluid, which is directly attributable to the prolonged distention of the intestine. Since this fluid loss is of equal magnitude in the oxygen and air breathing animals, it cannot be regarded as a factor in the more rapid death of the latter. The volume of fluid in both groups, even if regarded as a loss of circulating blood, represents only about 11 per cent of the total blood volume and is consequently not an adequate cause for the death of the animals in either group.

If the peritoneal fluid is to be explained as a transudate from engorged capillaries resulting from partial or complete venous occlusion, one might expect for the same reason a simultaneous increase in the fluid content of the intestine above that which is found in a nondistended gut. An increase in intraluminal fluid was, however, not observed. The average fluid content of the distended intestines in the oxygen and air breathing groups was about 13 cc. as compared to 11 cc. in the series of four similarly prepared but undistended animals. If excessive intra-enteric transudate does occur at some stage in the period of distention, one should expect to find in it those animals whose pressure remained high (well above normal venous pressure) up to the time of death. The data in Table I show no parallelism between final pressure and fluid content of the bowel. This is in accord with the findings of Gatch,[6] *et al.* There is an apparent contradiction between this finding and the well known clinical fact that overdistended and obstructed intestines usually contain excessive quantities of fluid. The animals studied in these experiments were starved and their intestines were relatively empty. In man the excessive fluids are probably to a large extent due to more or less fluid and

TABLE III

UNDISTENDED CONTROL ANIMALS

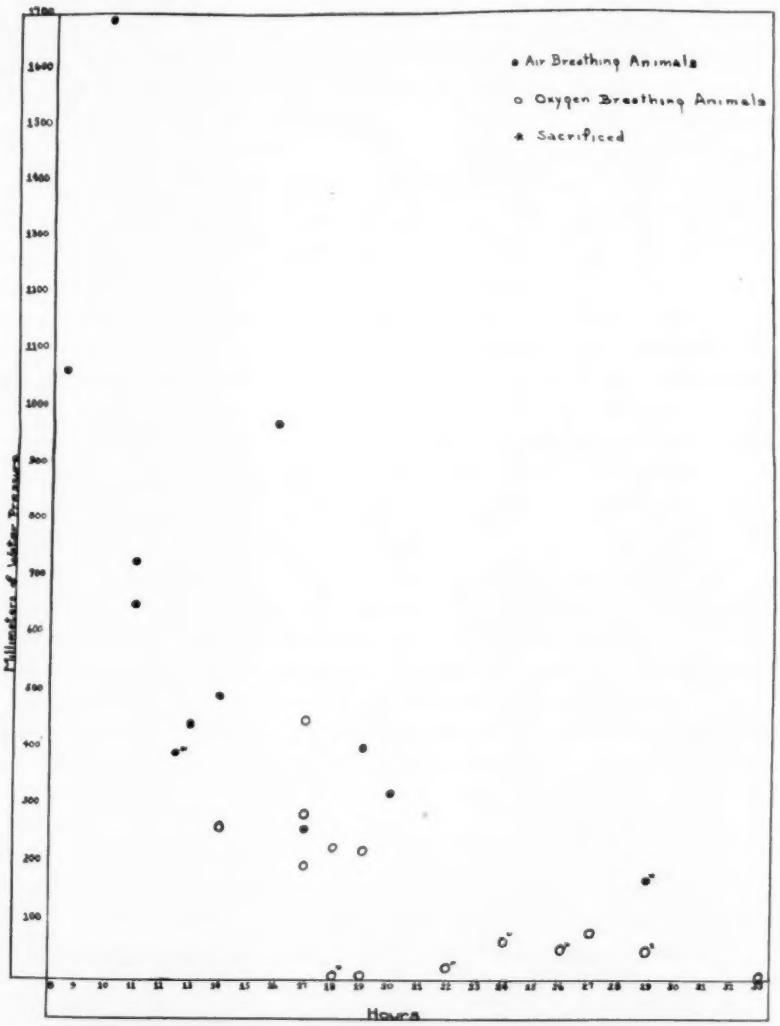
Small intestine ligated at pylorus and ileocecal valve. Cannula inserted into terminal ileum.

Experiment Number	Survival Time in Hours*	Peritoneal Fluid in Cubic Centimeters	Fluid Content of Bowel in Cubic Centimeters	Ratio of Bowel Weight to Body Weight in Per Cent
1	35	2	5	1.66
2	21	11	20	2.79
3	17	11	8	2.56
4	37	2	10	3.06

* Death in these animals due in part to regurgitation of citrate into the blood stream during continuous blood pressure observations.

food intake immediately preceding the onset or during the period of distention. There is no evidence in these experiments to substantiate Van Zwalenburg's[7] observation that the bowel mucosa at a distention pressure of 60 Mm.

CHART 6



RELATIONSHIP BETWEEN SURVIVAL TIME AND INTESTINAL PRESSURE AT TIME OF DEATH

Hg. "sweats" sufficiently to account for the increased fluid in the obstructed intestine in man. This does not, however, negate the possibility that excessive quantities of intraluminal fluid may accumulate at the pressure levels ordinarily observed in distention in man, which are very much lower than we have uti-

lized in these experiments and which have usually been established for a much greater period of time.

An average of the ratios of the weight of the small intestine to the weight of the animal shows no significant difference between distended and undistended animals (Tables I and III). There is, therefore, no evidence of an important loss of blood volume into the wall of the distended intestine. This agrees with similar findings by Aird[8] for closed loop obstruction. The evidence, therefore, is against fluid loss into the peritoneal cavity, bowel wall and bowel lumen as an explanation of the more rapid death of animals with high degrees of gaseous distention.

Of interest is the relationship between the survival time of the entire 26 distended animals and their intraluminal pressure at the time of death. Chart 6 shows that those animals with the lowest intraluminal tension appreciably outlived those which were unable to adequately decompress themselves, while high terminal pressures, as occurred in four of the distended animals breathing air resulted in very early death.

Comment.—The pathologic changes in ileus, aside from those due to actual strangulation, are produced by intra-enteric pressure alterations resulting from the accumulation of gas and fluid within the bowel lumen. The central problem in the therapy of obstruction, whether mechanical or functional, is the relief of increased intra-intestinal pressure. When the indications for surgical relief are clear, there is no better solution of the problem. Lacking such indications, the ordinary procedures for deflation are utilized, but unfortunately fail all too often. In such cases breathing 95 per cent oxygen, in accordance with a technic already described,[3] provides a method for effective deflation. Our experimental studies prove that breathing pure (or 95 per cent) oxygen results not only in a striking decrease in gas volume[1] but also in a marked reduction in the pressure within the lumen of the intestine. The lethal effects of a sustained high grade gaseous distention are thereby delayed or entirely avoided.

SUMMARY AND CONCLUSIONS

(1) When the obstructed small intestines of a group of 12 cats were distended with air or nitrogen up to a level of 800 Mm. of water pressure, death ensued in eight of these animals within an average of 11.7 hours following the establishment of this pressure level.

The intra-intestinal pressure in these eight animals fell from the initial level of 800 Mm. of water to an average minimum of 433 Mm. of water.

In the remaining four animals of this group a secondary rise in pressure occurred with resulting rapid death after an average survival time of only 5.25 hours.

(2) In a group of 14 cats, similarly treated, but breathing pure oxygen from the time the initial pressure level was established until termination of the experiment, the survival time was much longer. The average was 18.8 hours for eight animals which died and 25 hours for six which were sacrificed while still in good condition.

Eight of this group reached a final intraluminal pressure within or close to normal limits (20 to 40 Mm. of water), while the remaining six reached an average final pressure of 273 Mm. of water pressure.

(3) Evidence is offered to show that gaseous distention produces an increase in peritoneal fluid, but no appreciable change in the weight of the bowel wall. When the entire small intestine of the starved cat is converted into a closed loop distended with air to a pressure of 800 Mm. H_2O, there is no increase in the fluid content of the intestine.

The shorter survival time of the air breathing distended animals cannot be accounted for on the basis of fluid loss into the peritoneal cavity, bowel wall and intestinal lumen.

(4) Breathing pure oxygen is an effective means of reducing the intraintestinal pressure and of prolonging the survival time of cats in which the obstructed small intestine is distended with air or nitrogen.

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IMPORTANT STEPS IN ASEPTIC INTESTINAL ANASTOMOSIS

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CERTAIN axioms have been accepted in regard to this problem. It is agreed that such a resection may not be strictly aseptic. It is well known that a Lembert type of suture occasionally enters the intestinal lumen and is thus contaminated. However, the degree of asepsis maintained can be made greatly superior to that obtained in an open operation. The results following such an aseptic technic indicate that if there has been some degree of contamination, it has usually been cared for without reaction.

In 1922, the writer[1] detailed a procedure which had been developed to effect an aseptic intestinal resection, and has keenly watched the interest that has been manifested in the subject since that time. As steps in the technic have been developed, surgeons now are generally accepting the aseptic technic of resection, where indicated, as superior to open methods. In an attempt, possibly, to standardize an aseptic technic, the writer wishes to emphasize steps that seem, to him, essential. Conditions requiring resection are often found unexpectedly, and in order that an aseptic method can be employed, when indicated, the method should be uncomplicated and adaptable to the instruments usually found in any surgical armamentarium.

In many of the contributions on this subject, we feel that three features have been overemphasized: First, that the inturned intestinal cuff is objectionable; second, that the first row of sutures should be interrupted mattress sutures; and third, that the crushing forceps should be quite narrow. In regard to the first point, Halsted,[2] his coworkers, and others, have shown that the inturned cuff soon disappears—the crushed portion by sloughing and the remaining by atrophy. In 62 resections that we have performed, by the method to be described, there has not been a symptom to indicate an obstruction, or other undesirable features, produced by the cuff. It is of more importance to have the suture line coapt the intestinal surfaces without tension, than to be greatly concerned about a slightly larger inturned cuff. As for the second point, namely, concerning interrupted mattress sutures in the first row, such sutures have many knots to bury and invite subsequent trouble. They strangulate the area they include, producing pressure necrosis, and afford a greater danger of leakage at such a point. Again, with interrupted mattress, or for that matter any type of interrupted suture in the first row, with the onset of distention of the intestine, the sutures become further separated and intestinal contents may escape. With a well placed

Submitted for publication November 8, 1937.

continuous suture, the intestinal distention tends to tighten the suture line. As for the third point—in regard to the size of the crushing forceps—it has been our experience, since the intestines are not handled but are held in position entirely by these forceps while the first suture row is being placed, that the forceps should be fairly wide and strong enough to crush and hold firmly. A narrow forceps will occasionally cut through or slip off at a crucial moment. A wider crushed portion of cuff will always slough away. The forceps should not have toothed tips, but should be rather of the ordinary straight Pean type, so that they will pull out easily after the first row of sutures is completed. The accompanying plate of illustrations will perhaps serve to emphasize the steps of the operative procedure we have employed.

Figure 1 (A).—The blood supply, especially in the colon, must be without question. An opening is made in the intestinal border of the mesentery near a well defined arterial branch. The intestinal wall is stripped clean of mesentery toward the segment to be resected, so that twice the width of the crushing forceps is cleared between the artery and the tip of the forceps. All surfaces of the intestine to be approximated by sutures must also be freed from fat tags or other extraneous tissues, so that peritoneal surfaces may come in contact. If after resection the blood supply to the parts to be anastomosed seems impaired, reapply other forceps in the same manner and again resect, until a good blood supply is demonstrable. Avoid handling the unresected portion of the intestine. Do not strip away its contents or apply any ligatures or rubber-covered forceps to hold the contents away from the crushing forceps.

(A) The exact manner of applying the crushing forceps in an end-to-end anastomosis is most important. The tip of the forceps must be placed exactly at the mesenteric border of the intestine in the cleared space—the proper distance from the arterial branch. If the tips extend beyond the border, they cannot be properly buried by the first suture row, and thus assure against leakage at that point when the forceps are withdrawn upon completion of that row. The crushing forceps can be applied at right-angles to the intestine; or, to make a larger lumen or to improve the blood supply, at an angle away from the part to be resected. If the lumina of the two ends to be anastomosed are not of the same size, the smaller end can be enlarged by resecting it at an angle, or a removable loop-ligature[1] can be applied to the larger end and the forceps applied over this to contract that end down to approximate that of the smaller one. A second straight forceps of any type is applied alongside the first and the intestine is cut through with a thin bladed cautery.

(B) After resecting and observing that the blood supply of both ends to be anastomosed is sufficient, the operator holds both Pean forceps in one hand with the cauterized ends of the intestine in apposition, the tips of the forceps even without rotation. He thus holds them throughout the placing of the first row of sutures. Crushed ends of intestine, with forceps removed before tying of sutures, cannot be depended upon to hold. Forceps left in

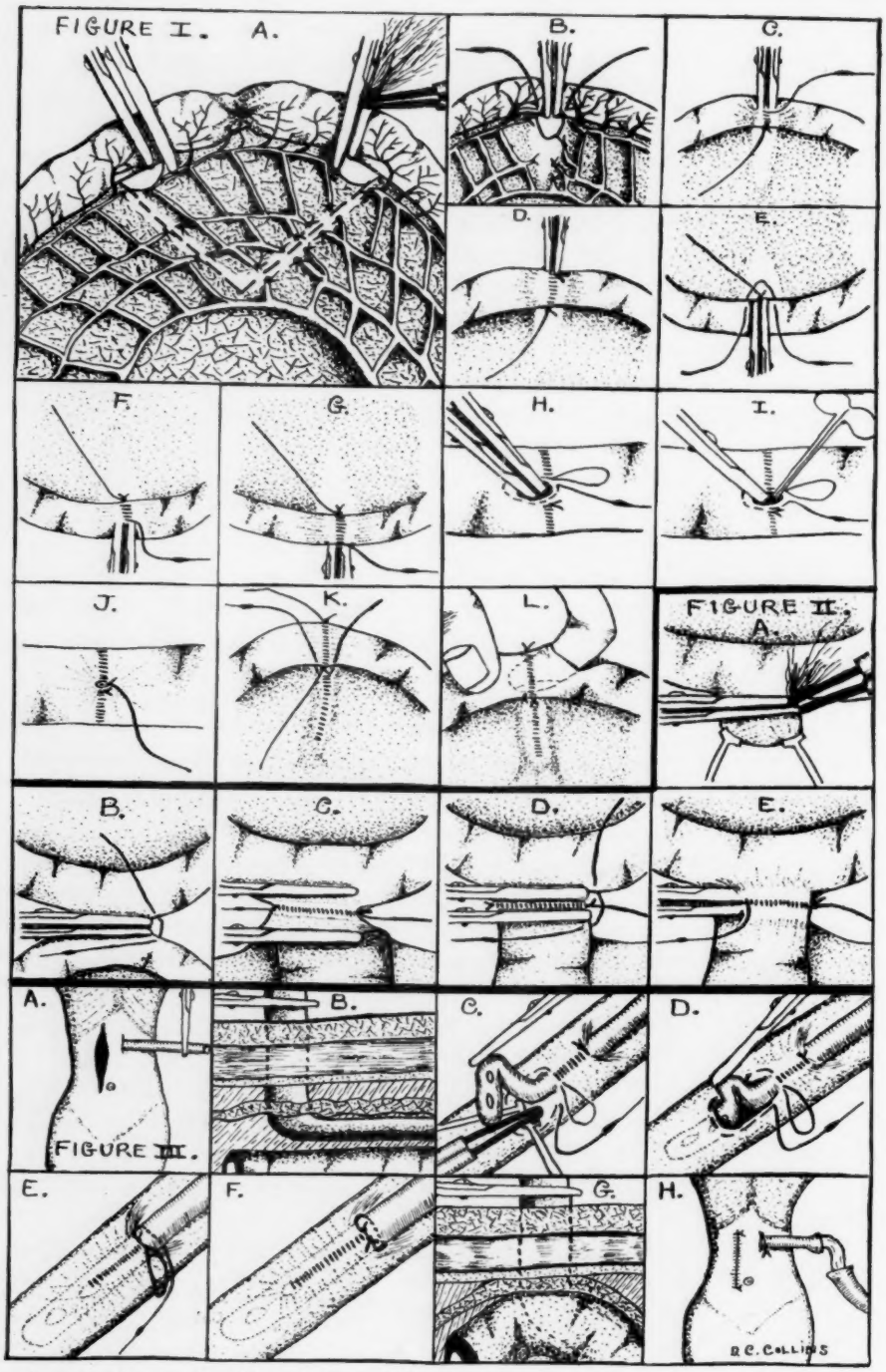

PLATE 1.—Incorporating Figures I, II, and III, descriptions of which are to be found in the text.

place while suturing are secure, assure a minimum handling of the intestine and are most convenient for holding a constant position.

Suture material for the first row, we believe, should be absorbable, chromic intestinal catgut mounted on a straight atraumatic intestinal needle, thus enabling the operator to estimate more accurately what intestinal layer is being transversed. Nonabsorbable suture material is cast off into the intestinal lumen. But when it is only partially extruded into the lumen, it may adhere to the intestinal canal, catching material and thus producing a possible degree of obstruction.

(B) The first stitch is of especial importance and is that one which is placed in the cleared space at the mesenteric border, between the arterial branch and the tips of the forceps on either end. It is so placed that when tied, the intestinal walls are drawn over the ends of the forceps so as to bury the tips. The suture end is left long so that it may be tied to a second suture, to be later placed in the opposite side.

(C) The tips of the forceps are now depressed and the suture continues as a continuous running Lembert suture covering in the forceps, as seen from the operator's side, and is tied when the shanks of the forceps are reached (D).

(E) The operator now, without changing the approximation of the forceps, rotates them in order to bring the other side of the intestine into view. A new suture is then started at the tips of the forceps, as in the first suture (F), and when it is tied, and retied to the end of the first suture already in place, the tips of the forceps are securely buried and there can be no gap at the mesenteric border in the first suture row. (G) This second suture is continued, as on the opposite side, until the shanks of the forceps are reached. (H) It is then purse-stringed around the shanks of the forceps and (I and J) is drawn snugly and tied as the forceps are removed. A suggestion is essential relative to the removal of the forceps: they are loosened and removed, one at a time, as the purse-string suture is tightened. There is a tendency for the crushed ends of the intestine to adhere to the forceps as they are withdrawn. (I) A small forceps or probe held on the cuff at the border adjacent to the crushing forceps, as it is withdrawn, will keep the cuff within the intestinal lumen.

(K) By holding the ends of the first row of sutures, the suture line is kept on tension and the second row is applied, not too closely, nor so tightly as to cause pressure necrosis. Started at the mesenteric border, this suture should close the split of the mesentery as it divides to go around the intestine, but care must be taken not to involve the arterial branch thus far preserved. This second row can be either of absorbable or nonabsorbable material, continuous or interrupted sutures. In the colon, a second row of absorbable material and a third row of nonabsorbable interrupted sutures may be advisable. (K) The closure of the mesenteric gap is made in the usual manner observing care again not to involve the important blood supply to the intestinal wall. (L) At this stage do not neglect to pass the tips of the thumb and a finger through the anastomosis to free the agglutinated ends of the

cuffs. One is surprised to find the ample lumen that is thus demonstrated. An omental tag or a free omental graft covering the suture line is an additional safeguard against leakage, particularly in a colon resection.

Figure II (A).—In a side-to-side anastomosis an ample pouch of intestinal wall is pulled up and clamped across, the tip of the Pean forceps not extending beyond the intestinal surface. This protruding portion of wall is excised between forceps with the cautery and the suturing is done (B) in an analogous manner as described for an end-to-end anastomosis. (C and E) However, as in performing an end-to-side ileocecostomy, or an ileotransverse colostomy, it may be best to place the two posterior rows first so as to facilitate suturing.

Figure III.—A number of times after resecting, we have thought it advisable, because of some degree of suspected ileus, to place an enterostomy tube proximal to the resection in order to prevent dangerous distention. Our concept concerning enterostomy is that the tube should be inserted for decompression in anticipation of trouble, rather than after symptoms are well established. In high resections of the small intestine, the use of the nasal duodenal tube for decompression, as suggested by Wangensteen,[3] may be employed in place of enterostomy, provided the tube is not allowed to reach the site of anastomosis. In resection of the left or transverse colon, a cecostomy performed as a first-stage operation decompresses both before and after resection. If an enterostomy tube is inserted, it should also be accomplished by an aseptic technic. (A) Through a stab wound of the abdominal wall, at one side of the incision, a fairly stiff No. 12 or 14 F. rubber catheter, with a clamp on its outer end (B), is passed into the abdomen and through the omentum. About 20 cm. proximal to the anastomosis, the tube is laid along the antimesenteric axis of the intestine that has been stripped of its contents and clamped off with soft rubber-covered forceps. (C) With a chromic intestinal suture on a straight atraumatic intestinal needle, a continuous Lembert suture buries the tube snugly for about 5 cm. Approximately 7 cm. of the tip of the catheter is left uncovered, turned up, and the same suture is purse-stringed about an area through which a puncture is to be made by cautery into the intestinal lumen. The cautery is employed after Allis forceps are applied within the purse-string suture to hold up the intestinal wall, and thus guards both the purse-string and the opposite intestinal wall from damage.

(D) The tip of the tube is guided into the cautery puncture with a forceps. (E) The purse-string is pulled tight, and the same suture continued back as a second invaginating row to the starting point. (F) At this point the suture is tied so as not to cut too tightly into the wall of the intestine. Against this knot the same suture is tied tightly about the catheter to anchor it in place. (G) The tube is then drawn up through the abdominal stab incision, drawing the enterostomy site snugly against the peritoneum with the omentum intervening. (H) A suture of nonabsorbable material is passed through the skin edge of the stab wound, tied loosely; and against

this knot, the tube is secured, giving it a second anchorage at this point.

The enterostomy tube is connected up for drainage and is kept open by injecting small quantities of warm, normal saline solution frequently, if indicated. The escape of gas alone may be all that is required to prevent distention. After a few days, when indicated, the skin suture is cut and the catheter is allowed to come away of its own accord. In the cases that we have operated upon in this manner, there were no fistulae that did not close spontaneously.

We have now resected, by the method described above, 19 of the colon and 43 of the small intestine, a total of 62 cases. In a *first group* of 36 cases, the condition of the intestinal wall seemed sufficiently good to allow of resection. These conditions were: Ten early strangulations; four of massive adhesions; three Meckel's diverticula; one stricture of the colon; one gastrocolic fistula; one granuloma of the terminal ileum; eight carcinomata of the colon; three duodenojejunostomies for duodenal obstruction; four ileotransverse colostomies for carcinoma of the ascending colon; and one colocolostomy for benign stricture of the sigmoid colon. In this group of cases, one died (2.8 per cent), a gastrocolic fistula, a portion of the stomach, jejunum, and colon being resected. A leakage occurred in the suture line of the transverse colon, resulting in a subsequent fatal peritonitis. This patient was a very poor risk from general inanition.

In a *second group* of nine resections the general conditions were poor, consisting of late obstructions with toxemia, and having intestinal walls that were questionable for suturing. In two cases pneumonia developed, which proved fatal. This group included one granuloma of the terminal ileum and cecum, five gangrenous, obstructed small intestines, one volvulus of the colon, and one carcinoma of the descending colon. In this group there were four deaths (44.4 per cent), one volvulus of the colon, one carcinoma of the splenic flexure of the colon, and two very extensvie resections for gangrenous strangulated ileum.

A *third group* of 17 resections were performed in 16 late obstructions of the ileum in whom ileus and toxemia were well established, when no type of operation offered other than a forlorn hope. Of these, 16 died (94.1 per cent). One case of carcinoma of the splenic flexture of the colon survived.

CONCLUSIONS

Of a total of 19 colon resections in the three groups, 16 (84.2 per cent) recovered. Of the three that died, two cases did not have a preliminary decompression because conditions did not permit.

If the 16 deaths in the third, apparently hopeless group can be eliminated from this consideration, there were then 46 resections in groups one and two with five deaths, a mortality of 10.8 per cent.

We believe that enterostomy, performed at the time of resection, is indicated in some cases to help recovery of the intestine by preventing distention and ileus. This is particularly true in such cases as are represented by

groups one and two. We have proved its value in a large group of cases, not included in this paper, where strangulating bands were freed without resection. However, enterostomy seemed without value in such cases as represented by group three.

If the condition of the intestinal walls justifies suturing, aseptic resection can be undertaken with confidence.

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TRANSIENT ACUTE PANCREATITIS*

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There has been a notable trend in recent years to distinguish between two groups of acute pancreatic disease. The picture of acute pancreatitis characterized by a fulminating attack of epigastric pain associated with massive necrosis of the pancreas and fat necrosis of the peritoneal structures is well known. Included in this group and probably representing different stages of the same pathologic process are the so-called "acute hemorrhagic pancreatitis," "acute suppurative pancreatitis" and "acute pancreatic necrosis." The other group, which has only recently obtained more concise definition, has been variously termed "acute pancreatic edema" by Zoepffel[1] and Archibald,[2] "subacute pancreatitis" by Stetten,[3] "acute interstitial pancreatitis" and "acute transient disease of the pancreas" by Elman.[4, 5] It is with this latter group that our study is primarily concerned.

Penín[6] attributed the earliest descriptions of edematous pancreatic lesions to Salsted (1890), Villard and Brance (1909), and Mercade (1919).

Zoepffel (1922) described a group of four operated cases of acute pancreatitis characterized by a complete lack of necrosis, and a glossy edematous infiltration of the pancreas, lesser omentum and transverse mesocolon. Microscopic examination of sections excised from two cases showed a marked interstitial and interlobular edema.

Archibald (1929) described experiments in cats in which he caused bile to flow through a small cannula from the common bile duct into the main pancreatic duct. Within a few minutes there developed a marked edema of the pancreas which subsided the following day. He described one case of presumptive, acute edema of the pancreas in a young man. Such a condition, he felt, occurred with unrecognized frequency, and probably explained some cases of acute epigastric pain diagnosed inaccurately as biliary colic, acute intestinal obstruction, perforated peptic ulcer, *etc.*

Elman (1933) made a thorough review of the literature and collected 37 cases of "acute interstitial pancreatitis" including four of his own, in all of which edema and induration of the pancreas were demonstrated. In 1935, he[7] added six more cases to this series. Again in March, 1937, he[5] presented eight cases of presumptive, acute pancreatic disease of a transient nature, four with operative findings. Since the review by Elman,[4] in 1933, this type of lesion has been mentioned by Bachy,[8] Dragstedt, Haymond and Ellis,[9] Penín,[6] Vianna,[10] Moiroud and Dor,[11] May,[12] and Mahner.[13]

* This work was aided by the David May Fund. Submitted for publication February 4, 1938.

The lesion generally associated with these cases is one of noninflammatory interstitial (interlobular and interacinar) edema, frequently with leukocytic infiltration.[1, 2, 3, 4, 6, 10] According to Archibald the lesion results from a reflux of bile into the pancreatic ducts; Elman thought it might be caused by a transient obstruction to the main pancreatic duct. The relationship of acute pancreatic edema to pancreatic necrosis has been a subject of contention. Zoepffel, Stetten, Bachy and Penín were of the opinion that edema of the pancreas was an early stage of acute necrosis. Nordmann[14] described several cases, observed both at early operation and at autopsy, which progressed from an edematous type of lesion to one of necrosis. Schmieden and Sebening,[15] Archibald, Leveuf,[16] and May,[12] while agreeing that edema may be an early stage of necrosis, thought it frequently subsided without progression to fat necrosis. Walzel,[17] and Pólya (cited by Leveuf[16]) were not convinced of this relationship, but felt that acute edematous pancreatitis was a benign lesion which subsided spontaneously without progression to necrosis. Because our cases lack surgical or postmortem confirmation we are not prepared to venture a definite opinion on the relationship of transient acute pancreatitis to acute pancreatic necrosis. Using only clinical observations as the criteria upon which we based our conclusions, we are inclined to the opinion that progression to necrosis does occur, but the process can be interrupted spontaneously during any stage.

We have confined our case reports only to those cases which we feel fall into the group of transient acute pancreatitis. Cases of the necrotic, hemorrhagic or suppurative type, of which we have had several, have been excluded. From the records of the Jewish and City Hospitals, St. Louis, during the past three years, we have collected 21 cases whose symptoms and laboratory findings bear sufficient resemblance to the cases of Zoepffel, Katsch,[18] Archibald, Stetten, Elman, and others to warrant inclusion in this classification.

CASE REPORTS

Case 1.—E. U., female, age 43, entered the City Hospital May 10, 1935, complaining of excruciating pain in the upper abdomen of one day's duration, accompanied by intense nausea and vomiting and followed by jaundice. Temperature 98.8° F.; pulse 112; leukocyte count 12,000.

Examination disclosed a distinct icterus. There was generalized abdominal tenderness, most marked in the epigastrium. Muscle guard was limited to the epigastrium. *Laboratory Data:* The blood diastase, determined on admission by Somogyi's method,[32] was 1,500, an extremely high level (see discussion on blood and urinary diastase, p. 1037), but the following day it dropped to 168, a normal value, and there was an almost complete subsidence of pain. Blood sugar 74 mg. A plain roentgenogram of the abdomen revealed nothing significant. Cholecystograms failed to visualize the gallbladder. On May 21, 1935, the symptoms and abnormal physical findings having completely subsided, the abdomen was explored.

Operation.—A thin-walled gallbladder containing a few cholesterol stones was found. The pancreas appeared normal both grossly and microscopically. Cholecystectomy and appendicectomy were performed. The postoperative course was uneventful; and the patient was discharged June 2, 1935.

This is a case of biliary tract disease complicated by a transient attack of acute pancreatitis. The fact that operation at a late date revealed no pancreatic pathology is of no significance since the pancreas usually reverts to a normal histologic appearance within several days after the attack.

Case 2.—S. C., female, age 31, was operated upon in the Jewish Hospital April 25, 1935. In 1933, this patient had had an attack of sharp, sudden, severe upper right quadrant pain. These attacks had recurred several times during the next two years. On April 25, 1935, a cholecystectomy and choledochostomy were performed, and several small stones were recovered from the choledochus. At that time no diastase determinations were made.

Postoperative Course.—Two weeks after the operation the blood diastase was 56; there had been no previous determinations made. The patient was readmitted June 21, 1935, complaining of severe, sharp epigastric pain which had begun the day before, associated with nausea and vomiting. During the night the pain had become less sharp in character, but continued as a constant soreness and radiated to the right costovertebral angle. Temperature 101.4° F.; pulse 108; leukocyte count 12,600. There was marked epigastric and upper right quadrant tenderness but little rigidity. The liver was enlarged two fingerbreadths below the costal margin. There was a faint icteric tint to the skin. *Laboratory Data.*—On June 22, 1935, the blood diastase was 708. By June 25, 1935, most of the symptoms had subsided, and the blood diastase had dropped to 100. The icteric index was 15. The patient was discharged June 29, 1937.

Whether the recent attack of pain was due to a transient pancreatitis or to a combination of a transient pancreatitis and an overlooked choledochus stone was not ascertained. The biliary tract must, however, be considered the etiologic factor of the pancreatitis. The importance of pancreatitis as a cause of recurrent pain following cholecystectomy has been previously pointed out by Elman.

Case 3.—H. M., male, age 69, was admitted to the City Hospital December 2, 1935, complaining of epigastric pain of a week's duration. Two days before admission the patient had noticed the appearance of jaundice, and the following day the pain became more intense and sharper in character and vomiting began. There was intense itching of the skin. Temperature 100.2° F.; pulse 76; leukocyte count 24,200.

Examination disclosed moderate tenderness and slight rigidity in the upper right quadrant and epigastrium. *Laboratory Data:* On January 4, 1935, the blood diastase was 660; blood sugar 99 mg.; icteric index 90; and the pain had largely subsided. The following day the diastase had dropped to 150. Operation was refused and the patient was discharged December 8, 1935.

Case 4.—W. T., male, age 60, was admitted to the City Hospital January 29, 1936, complaining of a sudden attack of severe epigastric pain, which had begun 12 hours previously. The patient had had "stomach trouble" for 11 years, consisting mostly of epigastric discomfort two to three hours after meals; there had not been any hematemesis or tarry stools. No diastase determination was made at the time of admission. A preoperative diagnosis of perforated peptic ulcer was made and an emergency operation performed. No ulcer was found. The liver was moderately swollen and biopsy revealed a mild acute hepatitis. No mention of the pancreas was made.

Postoperative Course.—The patient was readmitted June 5, 1936, complaining of spasmodic, severe, sharp, cramp-like epigastric pains of several hours' duration accompanied by vomiting. Temperature 99° F.; pulse 80; leukocyte count 30,000. *Examina-*

tion revealed marked tenderness and moderate rigidity in the epigastrium. *Laboratory Data:* The blood sugar was 70 mg. The following day, after slight improvement had occurred, the diastase was 400. By June 8, 1936, the diastase had dropped to 66, and the blood sugar was 154. The patient was discharged June 11, 1936.

This patient probably had two major attacks of acute pancreatitis. While a major lesion of the bile ducts and gallbladder seems to have been ruled out, the microscopic appearance of the removed liver tissue, in conjunction with the high diastase and blood sugar values obtained after subsidence of the attack, suggest some degree of liver involvement. (See the discussion on the relation of acute pancreatitis to biliary tract disease, p. 1041.)

Case 5.—S. H., male, age 50, was admitted to the Jewish Hospital February 17, 1936, five hours after the onset of generalized abdominal pain, most marked in the epigastrium, accompanied by severe vomiting. An appendicectomy had been performed two years previously for an attack of lower right quadrant pain; otherwise there had been no previous abdominal complaints. Temperature 98° F.; pulse 96; leukocyte count 16,000.

Examination disclosed moderate, upper right quadrant and epigastric tenderness and slight epigastric rigidity. *Laboratory Data:* The urine showed a three plus sugar and a trace of albumin. The day after admission the blood diastase was 1,250. Simultaneous urinary diastase was 4,575. The blood sugar was 108 mg. The following day there was a moderate improvement in symptoms, and the blood and urinary diastase determinations were respectively 136 and 1,150. A plain roentgenogram of the abdomen revealed nothing significant. On February 21, 1936, after all symptoms had disappeared, the blood diastase was 100. The patient was discharged.

Case 6.—E. M., female, age 56, was admitted to the City Hospital September 11, 1936, complaining of intermittent cramp-like epigastric pains of three days' duration accompanied by vomiting and slight jaundice. For the past 25 years the patient had had less intense attacks of similar pain. Temperature 99.6° F.; pulse 90; leukocyte count 7,550.

Examination elicited moderate epigastric and upper left quadrant tenderness and some rigidity. *Laboratory Data:* The following day, September 12, 1936, the blood diastase was 2,000; blood sugar 64 mg. Two diastase determinations, on January 13, 1936, showed 600. The following day the patient left the hospital, preventing further studies. Her symptoms had completely subsided.

Case 7.—L. B., male, age 42, was admitted to the City Hospital September 18, 1936, with a history of intermittent, knife-like epigastric pain for five days, which, however, had become more intense during the past ten hours. The patient had been a heavy drinker for several years, and was intoxicated when the present illness began. Temperature 97° F.; pulse 120; leukocyte count 13,000.

Examination showed a middle aged male writhing with pain, and the skin was cold and clammy. There was marked tenderness and moderate rigidity in the epigastrium. *Laboratory Data:* The blood diastase taken shortly after admission was 750. The following day the pain became more generalized and a slight jaundice appeared. The blood diastase was 666; blood sugar 120 mg. Two days later, after considerable symptomatic improvement, the diastase was 132, and the icteric index 100. On September 23, 1936, the diastase had remained the same, but the icteric index had fallen to 40. Cholecystograms, September 28, 1936, revealed a normal functioning gallbladder. The patient was discharged October 3, 1936.

The history of alcoholism complicates this case. In addition to the presence

of an acute pancreatitis the patient probably also had a toxic hepatitis which may have accounted for the appearance of jaundice.

Case 8.—F. S., female, age 68, was admitted to the City Hospital October 19, 1936, with a history of intermittent, generalized abdominal cramp-like pains of one day's duration; during the last few hours they had become more constant. Several similar, but much milder, attacks had occurred during the preceding few years. Temperature 102.4° F.; pulse 130; leukocyte count 14,500.

Examination showed a markedly obese, elderly female, with labored respirations, resulting from the pain, and perspiring freely. A slight degree of icterus was noted. There was moderate epigastric and upper right quadrant tenderness and slight rigidity. A sensation of fulness in the left hypochondrium was noted. *Laboratory Data:* On the day following admission the blood diastase was 600; blood sugar 103 mg.; icteric index 50. On October 21, 1936, much symptomatic improvement occurred, and the blood diastase dropped to 180. Further work-up was refused and the patient was discharged.

Case 9.—T. C., female, age 51, was admitted to the Jewish Hospital February 18, 1936, 24 hours after the onset of sharp epigastric pain which radiated to the interscapular region, and was accompanied by vomiting and severe headache. For two years she had had recurrent attacks of epigastric and upper right quadrant pain of a less severe character, which were interpreted as originating from a pathologic gallbladder. This diagnosis was substantiated by a cholecystographic examination which revealed a poorly filling and moderately enlarged gallbladder. Temperature 98.6° F.; pulse 86; leukocyte count 12,000. There was no icterus.

Examination elicited marked epigastric and moderate upper right quadrant tenderness and rigidity. The liver was enlarged two fingerbreadths below the costal margin. *Laboratory Data:* On February 19, 1936, 12 hours after admission, the blood diastase was 1,155; blood sugar 86 mg. The following day there was a notable improvement in her symptoms and signs, and the blood diastase dropped to 250. The urinary diastase at that time was 1,250. Sugar tolerance test gave a normal curve. On February 24, 1936, the blood diastase was 167. Five days later she was discharged.

The patient was readmitted August 3, 1936, with a similar, but more colicky attack of epigastric pain of 12 hours' duration. Temperature 98.6° F.; pulse 86; leukocyte count 13,400. Her physical findings were similar except that, in addition, left costovertebral tenderness was noted. *Laboratory Data:* Blood diastase determined the day following admission was 1,500, and the urinary diastase 3,000. After symptomatic improvement, two days later, the blood diastase fell to 220. Cholecystograms, September 7, 1936, showed no gallbladder visualization.

Operation.—September 11, 1936: A celiotomy was performed. The gallbladder was removed and was found to contain many small, faceted cholesterol stones. The dilated choledochus contained several similar stones, and was drained. The pancreas was moderately enlarged and indurated, but no biopsy was taken. The postoperative course was uneventful.

This case presented two major attacks of acute pancreatitis of unquestioned biliary tract origin. The absence of obstructive common duct signs at any time is of interest in view of the finding of choledochus stones.

Case 10.—J. R., male, age 47, in 1928 had a cholecystectomy performed, at the Jewish Hospital, for a pathologic, calculous gallbladder. Four years later he developed an attack of upper right quadrant pain, suspicious of biliary tract colic. The following year (1933), after having had several similar attacks, he was reoperated. The common bile duct was thoroughly explored but no stones were found. One section of the choledochus presented a suggestive constriction. Since then similar recurrent attacks

of pain accompanied by vomiting, but without jaundice, have occurred. His most recent attack began on November 18, 1936. Two days later, after most of his symptoms had subsided, the blood diastase was 213; blood sugar 98 mg. Two urinary diastase determinations were 5,333 and 4,570. The following day the blood diastase had dropped to 94 and the urinary diastase to 1,600 and 1,450. On November 27, 1936, the blood diastase was 107 and the urinary diastase 800 and 460.

It is probable that most, if not all, of this patient's recurrent attacks of epigastric pain following cholecystectomy were the result of transient attacks of acute pancreatitis. While the initial blood diastase determination was not unusually high, it having been taken during the recession of the attack, the urinary diastase, which lags in its changes behind the blood diastase, was still considerably elevated. This indicates that the blood diastase was higher in the earlier stages of the attack than at the time it was determined.

Case 11.—I. K., female, age 32, was admitted to the Jewish Hospital January 17, 1937, with a history of intermittent, moderately severe colicky pains in the epigastrium and upper right quadrant of four days' duration, radiating to the interscapular region. Vomiting and flatulence were prominent symptoms. During the previous five years there had been several similar but less severe attacks. Temperature 101° F.; pulse 90; leukocyte count 12,900. The skin was slightly icteric.

Examination elicited moderate epigastric and upper right quadrant tenderness and rigidity. The following day most of the symptoms and signs had subsided. *Laboratory Data:* The blood and urinary diastase determinations were respectively 400 and 6,400; blood sugar 112 mg. The following morning the blood diastase had dropped to 110. Cholecystograms showed no gallbladder shadow. A plain roentgenogram revealed suggestive evidences of calculi. The patient was discharged January 22, 1937.

Case 12.—B. G., male, age 67, was admitted to the City Hospital March 23, 1937, with a history of sudden, severe, sharp epigastric pain of four days' duration followed by jaundice. Since the onset, the pain had become less severe but intermittent recurrences of a colicky nature occurred. Several years previously the patient had had a similar attack. Temperature 100.2° F.; pulse 100; leukocyte count 18,200. A distinct icteric tint to the skin was noted.

Examination elicited moderate epigastric and upper right quadrant tenderness but no rigidity. The patient was apparently improving at the time he was admitted. *Laboratory Data:* Blood diastase values, determined in the morning and afternoon, were respectively 600 and 392; blood sugar 123 mg.; there was no glycosuria. The following day the diastase fell to 240, but the blood sugar rose to 176 and the urine showed a four plus sugar reaction. The patient was discharged March 21, 1937, no further work-up having been permitted.

The appearance of hyperglycemia and glycosuria during the fall in blood diastase is not an uncommon occurrence. It can be explained on the assumption that a certain amount of liver damage has occurred. (See discussion under carbohydrate tolerance, p. 1041.)

Case 13.—I. T., female, age 39, was admitted to the City Hospital April 17, 1937, complaining of intermittent, severe colicky pains in the epigastrium and right upper quadrant of eight days' duration radiating to the right scapula. Nausea was severe, but vomiting had occurred only once on the day before admission. A number of similar but less severe attacks had occurred during the previous 15 years. Temperature 99.4° F.; pulse 76; leukocyte count 12,300.

Examination showed the edge of the liver three fingerbreadths below the costal

margin; it was quite tender. Moderate tenderness and slight rigidity in the epigastrium were present. By April 19, 1937, some improvement had occurred. *Laboratory Data:* April 19, 1937: The blood diastase values morning and afternoon were respectively 1,396 and 780; blood sugar 78 mg.; icteric index 3. By March 24, 1937, blood diastase had fallen to 60. Three days later cholecystograms revealed a normal functioning gallbladder, and the patient was discharged.

Case 14.—E. H., female, age 60, was admitted to the City Hospital April 30, 1937, complaining of an attack of excruciating upper abdominal pain of six hours' duration radiating to both scapular regions and accompanied by vomiting. Temperature 97.8° F.; pulse 98; leukocyte count 8,640. The respirations were labored.

Examination elicited marked tenderness of the entire upper abdomen, but no rigidity. *Laboratory Data:* May 1, 1937: The morning and afternoon blood diastases were respectively 1,998 and 1,710; blood sugar 122 mg. The following day there was considerable symptomatic improvement and the diastase was 1,092. By May 3, 1937, the patient was greatly improved; the blood diastase had fallen to 168, and she was discharged.

Case 15.—F. K., female, age 45, was admitted to the Jewish Hospital February 11, 1935, complaining of sudden, severe epigastric cramping pain of ten hours' duration accompanied by vomiting. Temperature 99.6° F.; pulse 95; leukocyte count 20,250.

Examination elicited a moderate amount of tenderness confined entirely to the epigastrium, but no rigidity. The following day there was some symptomatic improvement, but a moderate tenderness persisted. *Laboratory Data:* The blood diastase at that time was 570 and the blood sugar 196 mg. No glycosuria was noted. On February 14, 1935, a sugar tolerance test showed a markedly diabetic curve, and the patient was placed on a diabetic regimen. At that time, except for slight residual epigastric tenderness, the symptoms and signs had subsided. On February 16, 1935, the blood diastase was 180; blood sugar 74. Cholecystograms, February 27, 1935, revealed a normal functioning gallbladder. A second sugar tolerance test, February 28, 1935, showed a better carbohydrate tolerance. The patient was discharged March 7, 1935. A subsequent sugar tolerance test showed a normal curve.

This case offers an excellent example of the decreased carbohydrate tolerance sometimes associated with an attack of acute pancreatitis. (See discussion under carbohydrate tolerance, p. 1041.) While this patient was at first considered diabetic, subsequent analyses did not bear out this conclusion.

Case 16.—S. C., female, age 68, was admitted to the Jewish Hospital April 26, 1937, for study following a series of attacks of upper right quadrant pain radiating to the right shoulder and back. These attacks began several months after a cholecystostomy had been performed, five years before, for acute gangrenous cholecystitis. She was a known diabetic, and had been well controlled under a dietary regimen.

Subsequent Course and Laboratory Data.—On admission the blood diastase was 84; blood sugar 151 mg. Two days after admission cholecystographic examination showed a poorly functioning gallbladder containing questionable calculi. On the night of April 29, 1937, she developed an attack of severe upper right quadrant and epigastric pain radiating to the interscapular region. Temperature 99.6° F.; pulse 80; leukocyte count 9,150. The following morning the blood diastase was 1,600; urinary diastase 5,714; blood sugar 269. By May 1, 1937, the symptoms had subsided and the patient was discharged. No further diastase determinations were made.

This attack, which by most observers would be considered an attack of biliary colic, was probably of pancreatic origin.

Case 17.—F. R., male, age 75, was admitted to the City Hospital May 7, 1937, complaining of severe, sharp upper abdominal pain of six hours' duration accompanied

by vomiting. Similar previous attacks had occurred during the preceding seven months, during which time roentgenologic examination of the gallbladder gave inconstant findings. Temperature 99.6° F.; pulse 100; leukocyte count 15,800.

Examination showed the entire upper abdomen, particularly the epigastrium, to be extremely tender. Muscle guard was noticed only in the epigastrium. *Laboratory Data:* The blood diastase values in the morning and afternoon were respectively 1,200 and 918; urinary diastase 8,040. The icterus index was 50; blood sugar 109 mg. During the following few days there was a gradual improvement in symptoms and signs. By May 10, 1937, the blood diastase had dropped to 150 and the following day to 120. The icterus index was then 60. The gallbladder was not visualized on cholecystography. The patient was discharged May 22, 1937.

Case 18.—A. G., female, age 65, was admitted to the Jewish Hospital May 10, 1937, 36 hours after the onset of an attack of severe, generalized abdominal pain accompanied by vomiting. The pain persisted as an intense aching, interrupted at frequent intervals by knife-like thrusts in the epigastrium. Temperature 100.4° F.; pulse 96; leukocyte count 22,450.

Examination elicited extreme tenderness and moderate rigidity in the epigastrium and upper right quadrant; the rest of the abdomen was less tender. *Laboratory Data:* The blood diastase on admission was 1,778; blood sugar 109 mg. The following day there was much symptomatic improvement but upper abdominal tenderness persisted. The blood diastase fell to 376, and the urinary diastase was 4,286. The abdominal symptoms had entirely subsided by May 14, 1937. The following day there was an elevation of temperature and pulse, and the patient complained of pain and dyspnea. Signs of fluid in the chest were found and roentgenologic examination showed a bilateral hydrothorax. This gradually cleared up spontaneously. Cholecystograms, May 19, 1937, showed poor gallbladder visualization. By May 21, 1937, the blood diastase had fallen to 278, and the urinary diastase to 800; on May 24, 1937, the blood diastase was 147. The patient was discharged May 26, 1937.

Case 19.—H. P., male, age 65, was admitted to the City Hospital June 29, 1937, six hours after the onset of an attack of excruciating upper abdominal pain which bore little resemblance to his previous epigastric discomfort. It began, just before the time for his evening meal, as an aching pain, and within two hours had become so sharp and penetrating that it caused him to "double up." Vomiting had occurred once. An attack of similar nature was recalled as having occurred two years previously. Temperature 99.6° F.; pulse 80; leukocyte count 7,100. The patient gave a history suggestive of the presence of a peptic ulcer of at least eight months' duration, characterized by a gnawing epigastric pain coming on one-half to one hour after each meal, which could always be relieved by the ingestion of food or alkalis.

Examination elicited marked tenderness of the entire upper abdomen, particularly the epigastrium. A tentative diagnosis of perforated peptic ulcer was made, but roentgenologic examination showed no evidence of pneumoperitoneum. *Laboratory Data:* Blood and urinary diastase determinations, soon after admission, gave values respectively of 2,400 and 24,000; blood sugar 158 mg. That afternoon the blood diastase was 3,000. The following day there was considerable improvement in symptoms. Moderate epigastric tenderness was still present, but no rigidity was noted. The blood diastase had fallen to 990. By July 2, 1937, the symptoms had completely subsided and the blood diastase had fallen to 120. Gastro-intestinal and cholecystographic roentgenograms showed no abnormal findings. The patient was discharged July 9, 1937.

Although the suggestive ulcer history cannot be completely disregarded in this case, the present attack resembled most closely one of transient acute pancreatitis. We are of the opinion that the diastase determinations saved this patient from a celiotomy.

Case 20.—B. S., female, age 66, was admitted to the Jewish Hospital September 20, 1937, ten hours after the onset of an attack of sudden, severe generalized abdominal pain mostly localizing in the upper right quadrant and epigastrium. Vomiting had occurred once. Temperature 99.4° F.; pulse 88; leukocyte count 19,300.

Examination elicited diffuse abdominal tenderness and rigidity, which was most marked in the epigastrium and upper right quadrant. Roentgenologic examination showed no evidence of subdiaphragmatic air or intestinal patterning. *Laboratory Data:* Blood and urinary diastase determinations were respectively 3,780 and 12,500. The following day there was considerable symptomatic relief, but tenderness in the upper right quadrant persisted. At that time the blood diastase was 2,370; blood sugar 88 mg.; icterus index 15. On September 23, 1937, the blood diastase fell to 226, and the pain had completely subsided. On September 27, 1937, the patient developed another attack of a similar but less severe nature, and some jaundice was noted. The following day the jaundice was more intense, and the icteric index was 40. The blood diastase showed an increase to 985. By September 30, 1937, the second attack had subsided; the jaundice disappeared; the blood diastase had fallen to 180. The patient was discharged.

Case 21.—E. L., male, age 33, was admitted to the Jewish Hospital November 17, 1937, for study following a series of attacks of upper abdominal pain suggestive of gallbladder disease. Two months previously the blood diastase had been normal. The day before admission some jaundice was noted. Cholecystograms revealed a poorly outlined gallbladder with questionable calculi. The day after admission the patient developed an attack of moderately severe, sharp epigastric and upper right quadrant pain. The temperature and pulse were normal; leukocyte count 12,000.

Laboratory Data.—The blood diastase was 1,113. By November 19, 1937, the attack had subsided, and the blood diastase had fallen to 169. The patient was discharged November 23, 1937.

The clinical features of the cases cited are not sufficiently distinctive at the time of admission to suggest readily a diagnosis of transient acute pancreatitis. Most characteristically the attack begins with sudden, severe upper abdominal pain radiating at times to a corresponding area on the back or to either shoulder. Nausea or vomiting may or may not be present. Depending upon the severity of the attack, signs of shock may be demonstrable. Occasionally there is a history of similar previous attacks. Examination usually reveals marked tenderness of the upper abdomen and rigidity of varying degrees. Early in the attack the temperature and pulse are usually normal; later they may be elevated. The leukocyte count is usually high. It can readily be seen that such a picture, one which may accompany several upper abdominal and even extra-abdominal disorders, is hardly conducive to more than consideration of the possibility of acute pancreatitis. One must, therefore, rely upon laboratory studies to help establish a diagnosis.

Such tests as the adrenalin-mydriasis test[20, 21, 22] of Loewi, examination of the pancreatic ferments by intubation of the duodenum,[24, 18, 23, 25] determination of the lipase in the blood stream,[26, 24, 18, 28, 27, 30, 25, 13] and of trypsin in the stool,[24, 18] examination of the fat contents of stool after ingestion of a test meal,[24] have given inconstant values, proven too slow of determination or impossible to perform on a patient so acutely ill.

Blood and Urinary Diastase.—The presence of diastase in the circulating blood and in the urine has been known for many years. There has accumu-

lated in the literature particularly during the last 35 years a mass of experimental data and clinical observations on diastase, much of which presents conflicting and confusing results and opinions. Many of the contradictory results of the earlier investigations, upon the origin and significance of the diastase, were probably due to differences and inaccuracies in the methods of determination, and should, therefore, be accepted only after thorough deliberation. Most investigators have now adopted the starch-sugar reduction method first performed on dogs by Kaufmann,[29] and on man by Moeckel and Rost,[31] and thereafter frequently modified. Even with a standardization and simplification of procedure, variability in starch preparations resulted in some errors in diastase determination. The use of soluble starch is one cause of conflicting results, since soluble starch shows great variations in composition, and, as a consequence, different starch preparations give different results with the same amount of diastase. The main source of errors in the older methods, according to Somogyi,[19, 32] is failure to recognize the kinetic laws of enzymatic reaction. In Somogyi's method, which we have used in our diastase determinations, due consideration is given to these factors, and one obtains consistent and reproducible results. Normal blood diastase values obtained with this method range between 80 and 180; meaning that 1,000 cc. of blood plasma incubated with starch for 30 minutes, under standard conditions, produce reducing substances that reduce as much copper as 80 to 180 mg. of glucose.

Diastase in Pancreatic Involvement.—Wohlgemuth[33] pointed out that the diastatic activity of the urine was increased in acute pancreatic disorders. Similar increases during pancreatic disorders in the urinary or blood diastase, or both, have been obtained by many investigators, including Hirschberg,[34] Benćzur,[35] Marino,[36] Lindemann,[37] Katsch,[18] Elman,[38] Elman, Arneson, and Graham,[39] Popper,[40] Bernhard,[41] Mushin,[42] Rost,[43] Branisteanu and Boutroux,[44] Foged,[45] Henderson and King,[46] Vianna,[10] Mahner,[13] and Trasoff and Scarf.[47] Increased diastatic activity has also been obtained in experimental acute pancreatitis produced by injecting, without pressure into the pancreatic ducts, a variety of chemicals, bacterial suspensions, and bile.[2, 9, 48] Further confirmatory evidence that the pancreas is involved in the production of diastase was obtained by ligation of the pancreatic ducts,[49, 50, 51, 52, 53, 54, 55] which procedure practically uniformly resulted in a rapid rise of the blood diastase lasting several days after which there was a return to normal. Similarly, experimentally induced trauma to the pancreas has resulted in increased diastase values.[56, 52, 57, 55] That the rise of blood diastase following ligation of the pancreatic ducts is due to a backing up of the ferment and absorption into the blood stream, and the subsequent fall consequent to atrophy of the secreting cells seems quite certain.[49, 50] The rise associated with trauma of the pancreas is probably the result of destruction of acinar membranes, diffusion of diastase into the interstitial tissue, and absorption into the blood stream. It is very likely that the rise associated with acute pan-

creatitis is due to a combination of these factors, inflammatory or spastic occlusion to the duct system and interstitial absorption of diastase.

That the pancreas is not the sole source of blood diastase seems reasonably certain. Complete pancreatectomy does not result in a permanent absence of circulating diastase. On the contrary, after an initial drop in the diastase following pancreatectomy there is usually a return to normal or slightly subnormal levels.[58, 59, 50, 52, 60, 61, 62] Some investigators[63, 64] have found little or no change following pancreatectomy; others[65, 66] have found even an increase. Furthermore, atrophic changes in the secreting cells following ligation of the pancreatic ducts are not accompanied by a permanent, and seldom by a temporary, decrease in the diastase.[51, 48, 55] Considerable evidence, discussion of which is out of the scope of this paper, has accumulated to consider the liver and muscle tissue as the possible additional source of circulating diastase. The pancreatic diastase (as well as lipase and trypsin) seems to enter the blood stream only after certain damages to the gland, such as acute inflammation and trauma.

For practical purposes we may conclude that normal individuals maintain a fairly constant level of blood diastase;[67, 24, 19, 55] that different individuals show variations of as much as 100 per cent within the normal limits;[35, 52, 68, 69, 19] that diastase is excreted in the urine with little diurnal variation;[70, 67, 24, 52] that physiologic functions, such as food ingestion, exercise, and sleep, have little effect on the diastatic values of the blood;[63, 65, 67, 71, 66, 72, 73] that the blood-urine diastatic ratio is quite constant except when the renal function is deranged, in which case the blood diastase is increased and the urinary diastase decreased or unchanged;[74, 75, 24, 76, 72, 77, 44] that following a rise in the blood diastase, unless there is an impairment of kidney function, there results in two to five hours a corresponding rise in the urinary diastase.[54, 24, 72]

Importance of Diastase in Diagnosis of Acute Pancreatitis.—Since blood diastase values remain so constant in normal individuals, the sudden marked rise associated with acute pancreatic disease is highly significant. Unger and Huess,[78] Walzel,[17] Kaczander,[79] Bernhard,[80] Peterson,[81] and Mahner[13] have expressed the belief that elevated diastase values are always indicative of acute pancreatic disease. With this statement we can agree, provided that a clinical picture resembling acute pancreatitis is associated. During routine diastase determinations on several hundred admissions to the Jewish Hospital, we have noted a few persistently high diastase values without obvious cause. High blood diastase values have also been obtained in cases of renal impairment. Furthermore, our records reveal several high diastase values in cases of peptic ulcer perforating acutely into the pancreas.[114] Excepting perforations of this type, in no other common condition confusable with acute pancreatitis, has there been demonstrated an increase in the blood diastase. Our many diastase determinations lead us to conclude that repeated normal blood diastase determinations made early during the height of an attack of acute upper abdominal pain exclude the pancreas from consideration. We make this statement with the full knowledge that there have been

three isolated reports of single cases of acute pancreatitis accompanied by normal urinary diastase values;[82, 45, 13] in none of these cases was the diagnosis confirmed by tissue examination, nor was the absence or presence of renal impairment mentioned.

The usefulness of diastase determinations in helping to establish a diagnosis of acute transient disease of the pancreas can be impaired if one is not careful to make early and repeated determinations. Foged[45] and Elman[5] have pointed out that as early as 36 hours after the onset of an attack of acute pancreatitis, and almost simultaneously with the disappearance of symptoms, the blood diastase may revert to normal. Our experience has been similar (Cases 1, 3, 5, 8, 11). Most clinics are familiar with cases which are admitted as emergencies, presenting symptoms and signs of acute upper abdominal lesions which rapidly clear up. At times they leave the hospital without a diagnosis having been made. Sometimes they are uncertainly or incorrectly diagnosed acute intestinal obstruction, biliary tract colic, perforating peptic ulcer, acute appendicitis or coronary disease. If early blood diastase determinations were made on cases of this type, it is very likely that a number would show elevated diastase values, thereby directing attention to the pancreas. We are of the opinion that the rôle of the pancreas in the production of epigastric pain has been frequently disregarded. The importance of daily, and sometimes twice daily, determinations can hardly be overestimated. Subsequent values reflect on the progression or retrogression of the attack.

Most investigators have made it a matter of personal choice as to whether diastase determinations should be made on the blood or on the urine. Of course, it would be preferable to do both, but frequently this is impractical. When there is a choice, blood determinations are preferable for several reasons. Normal blood diastase fluctuates less widely than normal urinary diastase. The latter varies between 200 and 800 and shows considerable irregular diurnal variation. Furthermore, derangement of renal function, undetected during an emergency, might mask the approximate level of the circulating diastase. On the other hand, since the urinary diastase follows fluctuations in the blood by a lag of several hours, urinary diastase determinations may furnish valuable information if made during the subsidence of an attack. In this condition the urinary diastase may remain elevated after the blood diastase return to normal. Case 10 is an example of the importance of urinary diastase determinations during the subsidence of an attack.

There seems to be no constant relationship in our cases between the severity of an attack and the level of diastatic activity. For example, Case 6 which was only of moderate severity had a maximum diastase of 2,000, while Case 4 which presented very severe symptoms had a maximum diastase of 400. These findings are in agreement with those of Walzel,[17] Pribram,[83] and Mahner.[13] They may be best explained by presuming that the determinations were made during different stages of the attack. The histories of our cases do not clarify this point.

Relation to Disease of Biliary Tract.—It is a fact that many cases of acute pancreatitis present signs and symptoms of precedent or concurrent biliary tract disease.[1, 15, 84, 2, 85, 86, 4, 87, 9, 88, 89, 90, 91, 46, 7, 25] At least half of our cases presented unmistakable signs of biliary tract disease, and several more have given presumptive evidence of this relationship. On the surface, this association would seem to confuse the differential diagnosis. Nevertheless, biliary tract disease *per se* is not accompanied by an elevated blood diastase. On the contrary, many cases of biliary tract disease when associated with impaired liver function present, according to Somogyi,[19] subnormal diastase values. This observation has been so constant, that in our laboratory the blood diastase has attained somewhat the status of a liver function test.* Since the majority of the cases of acute pancreatitis have some relationship to biliary tract disease, one would expect to find at times evidence of impaired liver function. Unfortunately the diastase increases that occur in acute pancreatitis are of such magnitude as to cover up completely the decrease that might result from the concurrent impairment of liver function. The decreased carbohydrate tolerance which occasionally occurs in these cases furnishes additional evidence of liver impairment. We are of the opinion that when a patient with biliary tract disease suddenly develops an elevated blood diastase one should be highly suspicious of the presence of pancreatic involvement.

Carbohydrate Tolerance.—Several investigators have noted that acute pancreatitis is frequently associated with hyperglycemia and glycosuria.[1, 2, 92, 3, 41, 93, 94, 95, 98] But many cases of acute pancreatitis occur without glycosuria. Henderson and King[46] noted glycosuria in only four of 60 cases, Love[21] in three of 30 cases, Walzel[17] in 10 per cent of his cases, and Elman[4] in six of 37 cases. DeKlimko[25] found an absence of reducing sugar in the urine of 19 cases. Vianna[10] thought glycosuria was a rare occurrence. We have made blood sugar determinations on all our cases. While an increase has been noted in several instances, it has not occurred with sufficient frequency to ascribe great significance to it. The emergency nature of many of these cases renders the securing of a fasting blood specimen at times impracticable. While we do not consider it an indispensable part of our diagnostic armamentarium, we recommend that a blood sugar determination be made, since it may add weight to one's diagnostic conclusions. It is interesting to speculate on the causation of hyperglycemia in acute pancreatitis. It is generally assumed that it results from a temporary dysfunction of the islands of Langerhans and consequent diminution of insulin. Brocq and Varangot[94] thought that some of the insulin was destroyed by trypsin. Against these hypotheses is the well known observation that many cases of acute pancreatitis can proceed to complete necrosis of the gland without the occurrence of hyperglycemia. We are of the opinion that a more tenable assumption

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would be the decrease of carbohydrate tolerance resulting from the associated impairment of liver function.

Treatment.—Once a diagnosis of acute pancreatitis has been considered likely, it is very dubious if the first examination will distinguish between a pancreatitis of the transient type or one which will progress to necrosis with its accompanying high mortality. The question will then arise as to whether the patient should be treated expectantly in an endeavor to establish a more accurate diagnosis or whether immediate operation should be performed. This question cannot be answered with certainty for it evokes a discussion of the highly controversial problem of the therapy of acute pancreatitis. For many years it has been the custom to operate as soon as a diagnosis of acute pancreatitis was considered even questionably tenable. It was well known that acute pancreatitis of the hemorrhagic, necrotic or suppurative types has been fraught with an extremely high mortality rate. Any procedure that offered the slightest chance of reducing this mortality rate was eagerly embraced. Because evidence greatly favored the theory of reflux of bile into the pancreatic ducts as the main etiologic agent of acute pancreatitis,[96, 15, 3, 85, 97, 98] such operative procedures as cholecystostomy, choledochostomy, cholecystectomy, and combined cholecystectomy and choledochostomy were advocated to decompress the biliary tract. Some surgeons advocated incision and drainage of the capsule of the pancreas, or of the gland itself, to relieve tension and to remove the products and cause of autodigestion. Others combined biliary decompression with pancreatic or lesser peritoneal cavity drainage. Using these procedures Koster and Kasman[99] reported a mortality rate of 22.7 per cent in 22 cases, and Quick[86] of 38.1 per cent. Brocq[95] noted a reduction or mortality rate from 78 per cent, before 1910, to 67 per cent, since 1910. Schmieden and Sebening,[15] and McWhorter[85] reported lower mortality rates in early operated cases than in unoperated cases. Other observers favoring early operative intervention are Zoepffel,[1] Waring and Griffiths,[22] Chamberlain,[100] Oehler,[101] Stetten,[3] Tammann,[92] Kappis,[102] Thomas,[103] Penin,[6] and May.[12]

Serious objections have been raised to the principles forming the basis for early operative treatment. While many observations attest to the relationship of biliary tract disease to acute pancreatitis, its exact nature is not known. Many cases of acute pancreatitis have been shown to have neither the anatomic configuration of the pancreatic and common bile ducts generally associated with these cases,[85, 104, 89, 9, 91] nor the clinical findings suggestive of an associated biliary tract disease (Cases 4, 5, 13, 14). Hofhauser (cited by De-Klimko[25]) has even implanted the pancreatic duct into the gallbladder without causing acute pancreatic disease. Furthermore, it is doubtful if drainage of the biliary tract could result in establishing patency in a pancreatic duct system already impaired by an edematous or inflammatory process. Drainage of the pancreas by incision of the capsule, or of the gland itself, can hardly be expected to arrest the process of acute pancreatitis. Nordmann[14] reported several cases, observed both at early operation and at autopsy, that progressed

to complete gland necrosis in spite of what he considered to be adequate biliary and pancreatic drainage. Walzel,[105, 17] Mikkelson,[106] Douglas,[107] and Telford[97] have expressed beliefs that pancreatic drainage may further damage an already severely compromised gland; may result in severe hemorrhage; promote massive slough of the gland; or may, if the patient survives, establish a pancreatic fistula. Walzel[105] was emphatic in condemning operative interference; he felt that acute pancreatic necrosis was not a bacterial necrotic focus that could be arrested by incision and drainage but purely a chemicobiologic process. Smead[108] thought that operation not only did not relieve the cause of shock but also added greatly to the seriousness of the case. Leveuf,[16] Grégoire,[109] and Moiroud and Dor,[11] while admitting that operation might be necessary to establish an adequate diagnosis, were skeptical of its offering anything from the standpoint of cure. Several investigators favoring early operative procedures did not submit their most acutely ill or moribund patients to operation. The mortality figures for their conservatively treated cases were, accordingly, abnormally high. Even those investigators favoring early operative intervention at times reported high mortality rates. For example, Oehler,[101] Tammann,[92] and Brocq[95] reported mortality rates of 58, 55, and 67 per cent respectively. In the hands of other investigators results of early operative treatment bordered on the disastrous. Eliason and North[110] reported a mortality rate of 80 per cent in their cases, Henderson and King[46] of 50 per cent, Nordmann[14] of 52 per cent, and Trasoff and Scarf[47] of 75 per cent. One is forced to conclude that the results of early operative intervention are highly unsatisfactory. At best the recovery rate in acute pancreatic necrosis averages no more than 50 per cent. Nor does the type of operation seem to influence the ultimate result.

More conservative measures have, accordingly, been adopted by many investigators. These have varied from operation as soon as signs of shock have largely abated to completely nonoperative procedures. Körte,[112] Walzel,[17] Nordmann,[14] Eliason and North,[110] deTakats and Mackenzie,[93] Bernhard,[80] Peterson,[81] Horine,[88] Henderson and King,[46] Johns,[91] Smead,[108] and deKlimko[25] favored conservative treatment during the period of acute symptoms, followed by operative exploration of the biliary tract when the acute symptoms had subsided. Mikkelson,[106] Felsenreich,[113] Rowland,[20] Parry and Murray,[89] Einhorn,[23] Douglas,[107] Mahner,[13] and Trasoff and Scarf[47] were even more conservative, advocating either no operation at all or operating at a later date only if biliary tract disease could be demonstrated. The results with more conservative measures, still far from a solution of the problem, have been more gratifying. Eliason and North[110] reported no mortality in their conservatively treated cases, Smead[108] a mortality rate of 7.5 per cent, Nordmann[14] of 22 per cent, and Mikkelson[106] of 7.5 per cent.

A thorough review of the literature, and a careful consideration of our cases, have convinced us that, until more specific measures are forthcoming to combat acute pancreatic disease, the best results will be obtained by conservative management of all cases. This applies not only to lesions of a transient

TABLE I

RÉSUMÉ OF 21 CASES OF PRESUMPTIVE, TRANSIENT ACUTE PANCREATITIS

Case	In Hospital	Sex	Age	Onset Before Admission	Pain	Vomiting	Jaundice	Tenderness	Rigidity	Leukocyte Count	Blood Diastase*	Urinary Diastase*	Blood Sugar†	Biliary Tract Disease	Remarks
1	5/10/35 6/ 2/35	F.	43	1 day	Upper abdomen ++++	++++	+++	Upper abdomen ++++	++	12,000	5/10/35 1,500 5/11/35 168		5/11/35 74	Present	Operated 5/26/35. Pancreas grossly and microscopically normal
2	6/21/35 6/29/35	F.	31	1 day	Epigastric and R.U.Q., radiating to midback +++	++	+	Epigastric and R.U.Q. +++	+	12,600	5/22/35 708 5/24/35 100		5/22/35 84 5/24/35 84	Present	Cholecystectomy and choledochostomy 4/25/35. No mention of pancreas. Postop. blood diastase 66
3	12/ 2/35 12/ 8/35	M.	69	1 day	Epigastric and R.U.Q. ++	++	+++	Epigastric and R.U.Q.	+	24,200	12/ 4/35 600 12/ 5/35 150		12/ 4/35 99	Present	
4	6/ 5/36 6/11/36	M.	60	12 hrs.	Epigastric ++++	+	o	Epigastric ++++	++	30,000	6/ 6/36 400 6/ 8/36 66		6/ 5/36 70 6/ 8/36 154	No evidence	Exploratory celiotomy performed several months before for similar attack, suspected perforated ulcer. Negative findings
5	2/17/36 2/21/36	M.	50	5 hrs.	Generalized abdom. +++	++++	o	Epigastric and R.U.Q. ++	+	16,000	2/18/36 1,250 2/19/36 136 2/21/36 100	2/18/36 4,575 2/19/36 1,150	2/18/36 108	No evidence	
6	9/11/36 9/13/36	F.	56	3 days	Epigastric and L.U.Q. ++	++	+	Epigastric and L.U.Q. ++	++	7,550	9/12/36 2,000 9/13/36 600 600		9/12/36 64	?	Left hospital before could be worked-up
7	9/18/36 10/ 3/36	M.	42	5 days(?)	Epigastric +++	o	+	Epigastric +++	++	13,000	9/18/36 750 9/19/36 666 9/21/36 132 9/23/36 132		9/19/36 120	Indeterminate	Chronic alcoholism. Intoxicated at onset of attack. Associated toxic hepatitis
8	10/19/36	M.	68	1 day	Generalized abdom. +++	++	+	Epigastric and R.U.Q. ++	+	14,500	10/20/36 600 10/21/36 180		10/20/36 103	?	Left hospital before could be worked-up
	2/18/36 2/29/36			1 day	Epigastric, radiating to interscapular region	+	o	Epigastric and R.U.Q.	++	12,000	2/19/36 1,150 2/20/36 250	2/20/36 1,250	2/19/36 86	Present	2/20/36 normal sugar tolerance curve

9		F.	51		+++			++										
	8/30/36 10/ 3/36			12 hrs.	Epigastric, radiating to interscapular region +++	+	o	Epigastric and R.U.Q. ++	++	13,400	8/31/36 9/ 2/36 9/ 4/36	1,500 220 167	8/31/36	3,000	8/31/36	93	Present	9/11/36 cholecystectomy and choledochostomy. Calculi in gallbladder and choledochus. Pancreas enlarged and firm
10	11/20/36 11/27/36	M.	47	2 days	Epigastric ++	++	o	Epigastric ++	++	11,800	11/20/36 11/21/36 11/27/36	213 94 107	11/20/36 11/21/36 11/27/36	5,333 4,570 1,600 1,400 800 460	11/21/36	102	Present	Three previous biliary tract operations
11	1/17/37 1/22/37	F.	32	4 days	Epigastric and R.U.Q., radiating to interscapular region ++	+++	+	Epigastric and R.U.Q. ++	++	12,900	1/18/37 1/19/37	400 100	1/18/37	6,400 1,714	1/18/37	112	Present	
12	3/23/37 3/31/37	M.	64	4 days	Epigastric ++	o	+++	Epigastric and R.U.Q. ++	o	18,200	3/23/37 3/24/37	600 392 240			3/23/37 3/25/37	123 176	Present	
13	4/17/37 4/28/37	F.	39	8 days	Epigastric and R.U.Q. +++	+	+?	Epigastric ++	+	12,300	4/19/37 4/24/37	1,396 780 60			4/19/37	78	No evidence	
14	4/30/37 5/ 3/37	F.	60	6 hrs.	Upper abdom. +++	+++	o	Epigastric +++	o	8,640	5/1/37 5/2/37 5/3/37	1,998 1,710 1,092 168			5/1/37	122	No evidence	
15	2/11/35 3/ 7/35	F.	45	10 hrs.	Epigastric +++	++	o	Epigastric ++	o	20,250	2/12/35 2/16/35	570 180			2/12/35 2/23/35	196 77	No evidence	Sugar tolerance curves Fast. 1h. 2h. 3h. 4h. 2/14/35—178 338 392 404 370 2/28/35—133 223 244 265 188 4/14/35—106 225 200 133 96
16	4/26/37 4/30/37	F.	68	Attack began in hospital	Epigastric and R.U.Q., radiating to interscapular region and rt. shoulder +++	+	o	Epigastric and R.U.Q. +++	+	9,150	4/26/37 4/30/37	84 1,600	4/30/37	5,714	4/26/36 4/30/37	151 269	Present	Cholecystectomy for acute gangrenous cholecystitis, four years before

TABLE I (*Concluded*)

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17	5/ 7/37 5/22/37	M.	75	6 hrs.	Epigastric ++++	++	+	Upper abdom. ++++	+++	15,800	5/ 8/37 1,200 5/10/37 150 5/12/37 120	5/ 8/37 8,040	5/ 8/37 109	Present	
18	5/10/37 5/26/37	F.	65	36 hrs.	Epigastric ++++	++	o	Upper abdom. ++++	R.U.Q. +++	22,450	5/10/37 1,778 5/11/37 376 5/21/37 278 5/24/37 247	5/11/37 4,286 5/21/37 893 800	5/10/37 109	No evidence	
19	6/29/37 7/ 9/37	M.	65	7 hrs.	Epigastric ++++	+	o	Upper abdom. ++++	++	7,100	6/29/37 2,400 3,000 6/30/37 990 7/ 2/37 120	6/29/37 24,000	6/29/37 158	No evidence	Suggestive previous ulcer history
20	9/30/37	F.	66	10 hrs.	Generalized abdom. +++	+	o	Upper abdom.	+++	19,300	9/20/37 3,780 9/21/37 2,370 9/23/37 226	9/20/37 12,500	9/21/37 88 9/23/37 74	Present	Observed during two attacks during this admission
	9/30/37			Attack began in hospital	Epigasytic and R.U.Q. ++	o	+++	Epigastric and R.U.Q. ++	+	13,800	9/28/37 985 9/30/37 180				
21	11/17/37 11/23/37	M.	33	Attack began in hospital	Epigastric and R.U.Q. +++	o	o	Epigastric ++	o	12,000	11/18/37 1,113 11/19/37 169		11/18/37 92	Present	

* Determined by Somogyi's method. Normal values 80 to 180.

† True sugar values. Normal 80 to 100 mg.

nature, but also to the more severe lesions of hemorrhage, suppuration and necrosis, from which many succumb regardless of the form of treatment. We have not been convinced that any operative procedure has lowered the mortality rate in acute pancreatitis of any type. While admitting that occasional abdominal exploration may become necessary to help establish a differential diagnosis, the careful use of diatase determinations should reduce the number of explorations to a minimum. If, on operation, evidence of acute pancreatic involvement is found, we are in favor of immediate closure of the abdomen without further interference. We believe that eradication of biliary tract disease should be delayed until the attack of acute pancreatitis has completely subsided. If death should ensue in the meanwhile, we are convinced that no operative procedure would have altered the ultimate result, but, on the contrary, might have hastened it. As additional evidence against early operative treatment we cite our cases of acute pancreatitis. The invariable recovery of these cases under expectant treatment we feel is further argument against operative interference in any case of acute pancreatitis.

CONCLUSIONS

Twenty-one cases of presumptive, transient acute pancreatitis are detailed.

The pancreas is a frequent source of acute upper abdominal pain often attributed to other upper abdominal disorders.

The examination, by newer methods, of the blood and urine for diastatic ferments, if performed early and repeatedly during an attack of acute upper abdominal pain, may furnish valuable assistance in establishing or excluding a diagnosis of acute pancreatitis.

Conservative management seems indicated in all types of acute pancreatitis during the acute stage. Surgical treatment of associated biliary tract lesions should be delayed until the attack of acute pancreatitis has subsided.

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SURGERY AND DIABETES

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DIABETIC patients, as a class, are not immune from those diseases which require surgical treatment. They may be affected by any of the diseases for which operation commonly is performed. In addition, there are certain diseases, such as cholecystitis and gangrene of the extremities, to which they are even more prone than is the average person. Surgeons no longer hesitate to operate upon patients with diabetes, as is proved by the large number of publications on surgical treatment of diabetics in the medical literature of the last decade. Since the advent of insulin, the average surgical mortality rate on diabetic patients has decreased enormously. This has resulted, not only from the use of insulin, but also from clearer understanding of, and improved technic in, the handling of the special problems involved.

Despite the great strides which have been made in the surgical care of diabetic patients, a great deal is yet to be accomplished, as can be seen by noting the wide range of results reported by various investigators. A good many physicians and surgeons, even yet, do not have a full comprehension of the importance of collaboration and team work between the physician and the surgeon, which is necessary if the singular needs of such patients are to be cared for adequately and satisfactorily. For the fact remains that, despite the more optimistic outlook made possible by the decreased mortality rate, an operation upon a diabetic patient is accompanied by more risk than one upon a patient who does not have this disease. Hence it is urgent that an ever-increasing number of surgeons and physicians know how to deal with the emergency presented by the diabetic patient who must be subjected to operation. The fundamental principles of treatment, both before and after operation, can not be stressed too strongly, nor repeated too often.

Surgical Mortality in Diabetes.—A glance at Tables I, II, and III shows a great decrease, since the use of insulin, in the death rate following operations upon diabetic patients. Reports published by four authors, both before and since the use of insulin, show that the average mortality rate without insulin was 40.6 per cent, while since insulin has been used, it is 16.0 per cent. This represents a decrease in mortality rate of 57.8 per cent, based on the average of percentage figures, without consideration of the number of cases involved (Table I). Table II shows the results in 2,023 cases reported by various authors, before the advent of insulin. The average mortality rate, calculated on the number of cases, was then 24.2 per cent. In a collective series of 14,231 cases, reported since 1924, the average mortality rate was only 5 per cent, although the range for individual reports was from 1.2 to 68 per cent (Table III). The statistics in these tables show that there has been a marked

Submitted for publication March 10, 1938.

TABLE I

SURGICAL MORTALITY IN DIABETES

Effects of Insulin

Author	Mortality		
	Before Insulin Percentage	After Insulin Percentage	Decrease Percentage
Reed[1] (summary of other authors)	34.04	12.7	64.6
Saunders[2]	62.5	24.5	59.4
Mason[3]	22.0	15.0	31.8
Beardwood[5]	44.0	10.9	75.3
Averages	40.63	16.0	57.8

TABLE II

SURGICAL MORTALITY IN DIABETES

Before Insulin

Series	Cases	Mortality Percentage
Berkman[6] (1921)	159	5.0
Lahey[7]	14	7.1
Berkman[8] (1916)	26	7.6
Joslin[9] (1919)	61	9.0
Young[11]	99	16.1
Cumston[12]	6	16.6
Joslin[9] (before 1917)	27	18.0
Binney[13]	32	19.0
Karewski[10]	225	21.0
Mason[3]	41	22.0
Morrison[14]	775	23.0
Jones[15]	8	25.0
Phillips[16]	101	27.0
Fitz[17]	45	30.0
Strouse[18]	38	31.3
Weeden[19]	160	36.8
Menninger[20]	47	42.5
Beardwood[5]	19	44.0
Fischer[21]	86	48.4
Saunders[2]	24	62.5
Nygind[22]	5	80.0
Gardner[23]	25	80.0
Totals	2,023	24.2

TABLE III

SURGICAL MORTALITY IN DIABETES

With Insulin

Series	Cases	Mortality Percentage
Adams and Wilder[24]	327	1.2
Allan[25] (1930)	288	1.7
Bruce[26]	97	2.1
Lemann[4]	43	2.3
Allan[25] (1931)	218	2.7
Bazin[27]	73	2.7
Judd, Wilder and Adams[28]	667	2.9
Mayo Clinic [29] (combined series from 1921–1932)	7,309	3.3
Eliason[30] (1929–1932)	170	3.5
Eliason[30] (1926)	50	3.6
Menninger[20]	22	4.5
John[71] (1925–1930)	462	4.7
Rabinovitch[31]	130	5.3
Joslin[32] (1923)	69	5.7
John (1920–1937)	1,273	5.8
Joslin [33] (1928–1930)	580	5.9
McKittrick[34]	1,002	7.6
Weeden[19]	12	8.3
John[71] (1921–1925)	35	8.5
Roth[35]	20	10.0
Joslin[36] (1925)	97	10.3
Beardwood[5]	91	10.9
McKittrick and Root[37]	80	11.2
Foster[38]	103	11.6
Petty[39]	31	12.6
Joslin[36] (1927)	322	12.7
Law[40]	15	13.3
Cohen[41]	8	14.0
Joslin[36] (1924)	75	14.6
Joslin[36] (1926)	81	14.8
Mason[3]	60	15.0
Ralli and Standard[42]	96	16.4
Reed[1]	64	18.7
Coller and Marsh[43]	65	24.6
Saunders[2]	14	25.4
Bauman[44]	56	26.7
White[45]	66	28.7
Carp[46]	25	35.0
Eliason and Wright[47]	55	41.8
Apfelbach[48]		68.0
Totals	14,251	5.0

decrease in the mortality rate in recent years, but they also indicate a tremendous variation in individual reports. This variation is quite difficult to account for, and does not represent merely a difference in the excellence of treatment, but depends also on the type of operation, the type of patient, *i.e.*, private versus charity patients, and other factors. The difference between the results in major and minor operations in my own cases is shown in Table IV.

TABLE IV

SURGICAL MORTALITY IN DIABETES

(JOHN)

Operations	Mortality Percentage
Major— 983	10.0
Minor— 290	1.7
Total —1,273	5.8

Causes for Decrease in Mortality.—Although the use of insulin has been a vitally important factor in the improvement of surgical results in the presence of diabetes, this also is dependent on other factors. Before insulin was available, operations upon a diabetic patient were often performed merely as a measure of last resort, and hence most procedures were of major character

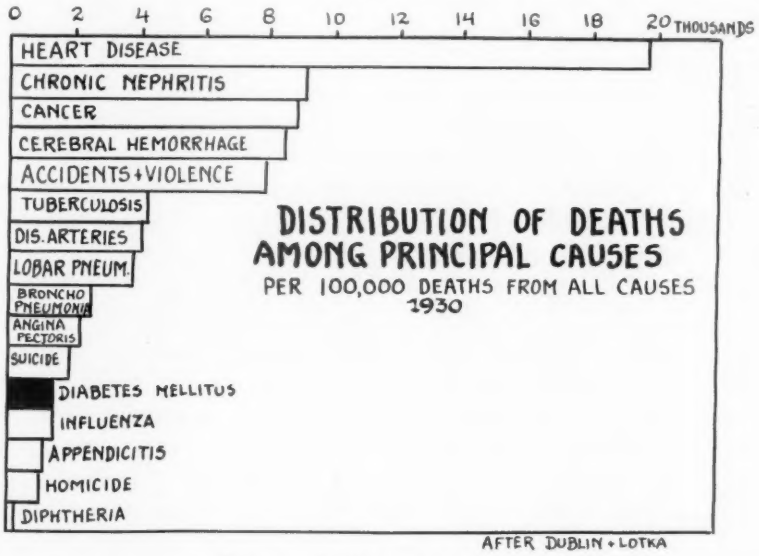

CHART 1.—Leading causes of death.

and entailed great risk. The newer anesthetics which are less hazardous have been developed since that time. The proper postoperative and preoperative care was not so well understood then as it is to-day. All of these factors increased the gravity of the prognosis for a diabetic patient who had

to be operated upon before the era of insulin, and many authorities felt that surgery should not be resorted to, unless it could not possibly be avoided.

Increase of Risk in Diabetic Patients.—It is not the diabetes *per se* that increases the risk of surgical operations in diabetic patients, for diabetes ranks ninth among the ten leading causes of death (Chart 1). Only 28 persons per 100,000 population die from diabetes, as compared with 261 per 100,000 who die as the result of heart disease. The principal factors which increase the surgical risk in the presence of diabetes are obesity, advanced age, arteriosclerosis and infection.

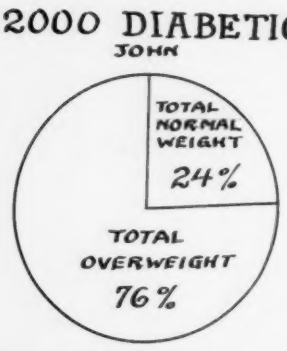

CHART 2.—Relative proportion of obesity in diabetic patients.

Any obese patient presents a poorer risk surgically than one who is thin. The proportion of stout patients among diabetics is far greater than among nondiabetics, and this naturally increases the number of deaths following operation (Chart 2).

Many operations upon diabetic patients are performed on those of considerable age, for diabetes is preponderantly a disease of advanced years. Chart 3 shows the increased mortality rate in patients more than 50 years of age. Aside from the actual age, diabetic patients are physiologically older than those without diabetes, because of the effect of the disease on the circulatory system. The approximate physiologic age can be estimated roughly by adding the number of years that diabetes has been present to the patient's actual age. Thus a person age 60, who has had diabetes for 16 years, is approximately 76 years old physiologically.

The resistance of the diabetic patient to infection is always less than that of a normal person, and this presents one of the major risks when the patient is operated upon. Hyperglycemia hinders speedy healing of the tissues, as has been pointed out by McKittrick[50] and by Lewis.[49] If serious infection develops following an operation, the diabetes may be markedly aggravated, and may even get beyond control.

SPECIAL SURGICAL PROBLEMS IN DIABETES.—*Cholecystitis:* That an infection of any kind aggravates diabetes is so well known that it requires no comment. While the statistics available do not give any precise picture of the relative proportions of diabetic and nondiabetic patients with gallbladder disease, it is a matter of common experience that diabetic patients are more prone to affections of this organ. The presence of cholecystitis, as based on routine autopsy records, has been reported by some authors as more than 20 per cent. McKittrick,[37] in a series of 24 diabetic cases, found an incidence of almost 35 per cent. While this series is too small to warrant a general statement, it is probably true that it is indicative of the greater proportion of patients with cholecystitis in diabetic patients.

Even as early as 1910, Mayo Robson[51] pointed out the relation of cholecys-

titis to diabetes, and stated that in many instances diabetes might be averted by the early removal of the gallbladder. Joslin[32, 33] has stressed this point, too, for many years.

Chronic cholecystitis is a mild infection, but still it affects the diabetic state adversely. It is extremely common to see marked improvement, with increased sugar tolerance, and marked diminution in the insulin requirement following cholecystectomy (Table V). Hence when a diagnosis of gall-

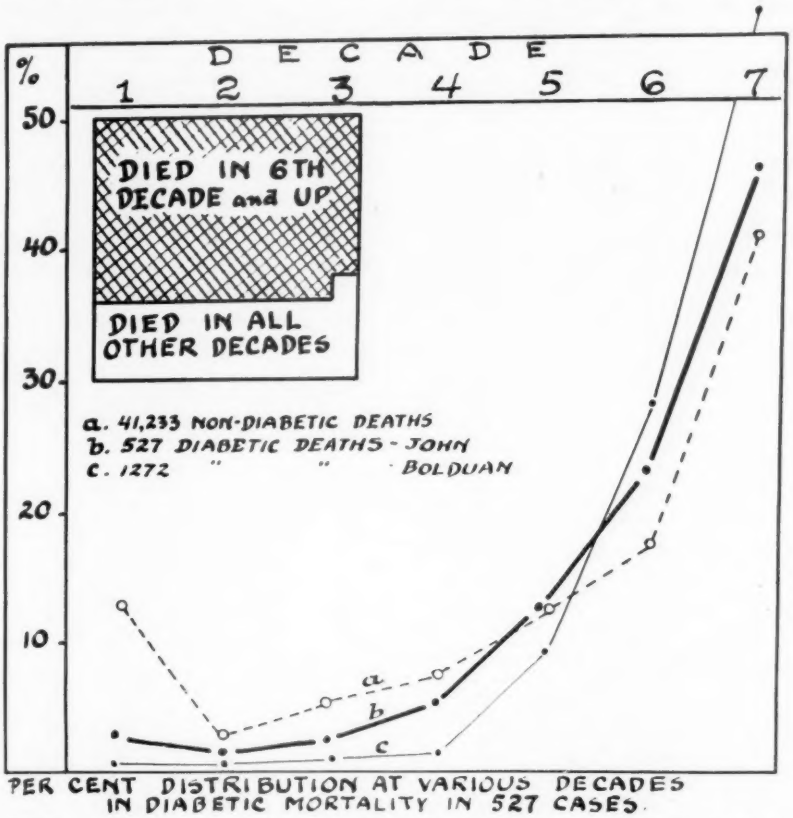

CHART 3.—Ordinates: Percentage distribution. Abscissas: Decades. The effect of age on surgical mortality.

bladder disease has been made, a diabetic patient can be promised improvement following cholecystectomy. This can be performed without undue risk, according to recent records of the results of this operation on diabetic patients. In a total of 216 cases, reported by nine authors, the surgical mortality was only 3.3 per cent (Table VA).

Gangrene of the Extremities.—Gangrene of the extremities is of common occurrence in diabetic patients, and usually requires surgical treatment. This condition, which is commonly called diabetic gangrene, would be more precisely referred to as arteriosclerotic gangrene, for it is of the same type as is seen in nondiabetic patients with arteriosclerosis. It is more common, how-

TABLE V

ANALYSES OF PRE- AND POSTOPERATIVE BLOOD SUGAR IN EIGHT CONSECUTIVELY CHOLECYSTECTOMIZED PATIENTS (JOHN)

	Sex	Age	Aver. Bl. Sug. Before Oper.*	Insulin Requir.	Aver. Bl. Sug. After Oper.*	Insulin Requir.
Mrs. P.	F.	60	210	45 Units	140	0 Units
Mrs. Pe.	F.	68	190	30 Units	85	0 Units
Mrs. La.	F.	47	190	20 Units	130	0 Units
Mrs. Sm.	F.	59	240	20 Units	160	15 Units
Mrs. La.	F.	50	238	30 Units	92	0 Units
Mr. Ke.	M.	52	200	60 Units	140	40 Units
Mr. Be.	M.	39	190	20 Units	160	15 Units
Mrs. Se.	F.	60	190	40 Units	130	25 Units

* The averages given are those obtained from three blood sugars on a check-up; namely, before breakfast, lunch and dinner, showing the increased degree of sugar tolerance and the lessened amount of insulin required postoperatively following cholecystectomy.

TABLE VA

SURGICAL MORTALITY IN DIABETES

Gallbladder Operations

Author	Cases	Mortality Percentage
Bazin[27]	10	0
Foster[38]	3	0
Joslin[35]	13	0
Lemann[4]	1	0
McKittrick[50]	59	0
Ralli and Standard[42]	2	0
Judd, Wilder, Adams[28]	40	2.5
John	43	4.6
McKittrick[37]	45	8.8
Totals	216	3.3

ever, in diabetic patients because they are more likely to have advanced arteriosclerosis. The occurrence of gangrene is conditioned far more by the vascular state than by the degree of diabetes. If the diabetes were the more important factor, as is still claimed by some authorities, it would be seen more commonly in patients with extremely high levels of blood sugar, who have neglected the proper treatment of the diabetic condition. But it seems that the greater proportion of those who have gangrene have mild diabetes, sometimes of short duration.

The actual incidence of gangrene in diabetes has been reported variously

as from 2.4 to 18 per cent. The average percentage of thirteen reported series is 5.2 (Table VI). If severe, uncontrolled diabetes were the important etiologic factor, it seems to me that this percentage would be much greater. However, it should be noted that some authors report a disparity in the incidence of gangrene in private and in charity cases. This may be due to neglect of other factors as much as to the lack of control of the diabetes. Gangrene has not decreased appreciably since the use of insulin, and there certainly can be no question that the general attention and care of diabetic patients has improved tremendously during this time.

TABLE VI

INCIDENCE OF GANGRENE IN DIABETES

Author	Cases	Gangrene Percentage
John	4,871	2.4
Mayo Clinic[25]	684	2.4
University of Pennsylvania Hospital (before 1923)	355	2.5
Paullin[52]	560	2.8
Joslin[53]	3,000	3.0
Lemann[54] (private cases)	471	5.3
Peter Bent Brigham Hospital[54]	969	7.0
Massachusetts General Hospital[54]	600	9.0
University of Pennsylvania Hospital (since 1923)	845	6.2
Tuoro Infirmary[54] (private cases)	201	10.0
Boston City Hospital[54]	967	11.2
Philadelphia General Hospital	1,305	13.0
Lemann[54] (charity cases)	439	18.0

The answer to the question of why there are varying degrees of arteriosclerosis in diabetic patients, whether well cared for or not, certainly has not yet been found. Since we do not know the cause of increasing arteriosclerosis, the best we can do is to make an effort to recognize the premonitory symptoms of circulatory insufficiency as early as possible, and thus to try to prevent the development of gangrene. A sensation of cold and pain in the feet, cramps in the calves of the legs, especially when lying down at night, are the first symptoms.

It has been pointed out by Starr[55] and others[56] that a considerable reduction in the peripheral circulation may occur without the development of any physical signs. On the other hand, the latter has also shown that the minute vessels may demonstrate normal responses even when the physical examination reveals gross evidence of arterial sclerosis. Starr has used histamine tests to detect the actual changes in the circulatory response. One-half of the diabetic patients he tested in this manner showed diminished circulatory

responses in the feet, and in 34 per cent this impairment was extreme. He asserts that the preponderant proportion of patients with gangrene are included in this latter group. Gangrene develops only when the reduction in circulation is of advanced degree.

The preventive treatment of diabetic gangrene is all aimed at stimulation of the circulation in the extremities. Among the measures which have been advocated are hot foot baths at night, contrast baths, woolen bed socks, and the positive-negative pressure pump. In the application of heat, care must be taken to prevent burning. Joslin[36] has also stressed particularly the cleanliness of the feet. Another important factor is extreme caution in cutting the toe nails, to prevent even a small injury which may not heal.

There is some controversy as to the efficacy of the leg pump in stimulating circulation. Some authorities, especially McKittrick,[34] have asserted that it is of no value when gangrene is already present. On the other hand, I have been impressed with the results in some cases of this type, for some feet have been saved which I am sure would have had to be amputated without the aid of this appliance. The contraindications to its use are: (1) Moist gangrene or spreading infection; (2) lymphangitis; (3) thrombophlebitis; (4) varicose veins; and (5) cardiac decompensation with edema.

TABLE VII

MAJOR AMPUTATIONS IN DIABETES

Author	Cases	Mortality Percentage
Maes[57]	60	5.0
Judd, Wilder, Adams[28]	15	6.6
Walters, Meyerding, Judd, Wilder[29]	86	11.0
McKittrick[37]	365	13.9
John	61	16.0
Foster[38]	31	19.0
Young[11]	19	21.0
Bothe[58]	60	22.0
Saunders[2]	25	24.0
Joslin[36]	56	27.0
Ralli and Standard[42]	36	33.0
Smith[59]	18	34.0
Reed[1]	13	38.0
Coley[60]	10	40.0
Eliason[30]		56.0
Apfelbach[48]		65.0

The mortality rate from amputations for gangrene ranges from 5 to 65 per cent (Table VII). Most of the high rates were reported by general hospitals whose patients represented poor risks because of lack of previous care and an advanced condition of the gangrene. Various factors affect the mortality rate in these cases. These include the type of infection, the age of

the patient, the degree of shock, and the degree of regulation of the metabolic disorder. When one considers the shock occasioned by an extensive amputation and the advanced age of most of these patients (Table VIII) it is easy to see why the mortality rate following this type of operation is higher than in many other conditions.

TABLE VIII

THE AGE AT ONSET OF DIABETIC GANGRENE

Author	Average Age
Bothe[58]	51
Lewis[61]	54
Eliason and Wright[47] (1926)	59.2
Joslin[35] (1923)	61
Eliason[30] (1932)	61.6
McKittrick and Root[37] (1928)	64.9
Eliason and Wright[30] (1931)	69.9

TABLE IX

SURGICAL MORTALITY IN DIABETES

Various Surgeons

Surgeon	Operations	Mortality Percentage
1	8	0
2	3	0
3	9	0
4	7	0
5	9	0
6	4	0
7	59	3
8	232	5
9	17	6
10	48	6
11	49	6
12	12	8
13	82	17

Collaboration of Internist and Surgeon.—Operation upon a diabetic patient presents a problem which requires the combined talents of an internist and a surgeon who are especially interested in diabetes. The published results attest to the importance of this collaboration. The best results come from perfect team work. A glance at the records from the Mayo Clinic, where such service and team work are highly organized, shows that the surgical mortality in diabetic patients is consistently low. In 1924, they[24] reported 327 operations upon diabetic patients with a death rate of 1.2 per cent; in

1930, 288 operations, with 1.7 per cent; in 1931, 218 operations with 2.7 per cent fatalities.[25]

These results should be encouraging to everyone interested in the problem of surgery and diabetes, for they show what can be accomplished when there is the proper interest and coordination of effort.

Citing from my own experience some records to show the importance of collaboration of surgeon and internist, which means the proper care of the diabetic patient, the recommended measures were taken before and after operation, but one surgeon refused to recognize the importance of these procedures and would not wait until the patient was deemed ready for the

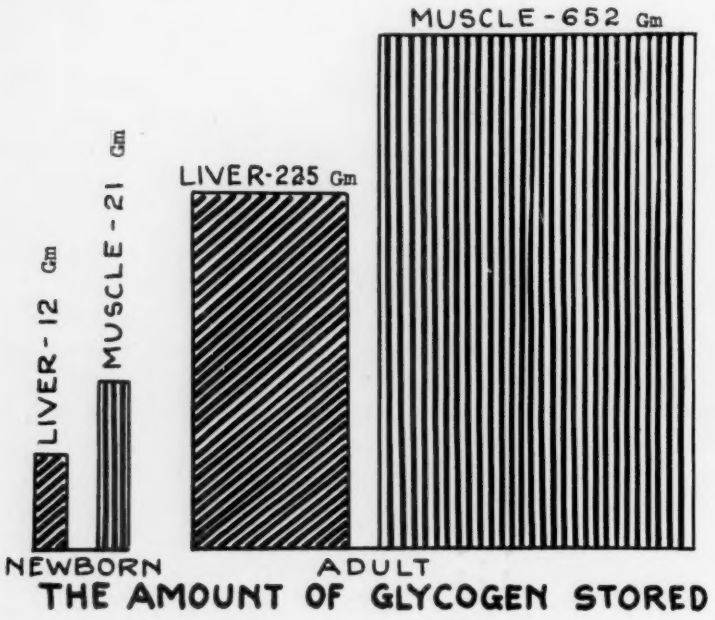

CHART 4.—The storage of glycogen in liver and muscles.

operation. The other 12 surgeons cooperated with me fully and accepted my judgment as to when the patient should be operated upon. Table IX shows the results. The first six surgeons had no fatalities, and the other six had a comparatively small number of deaths; but the operations performed by the obstinate surgeon resulted in death in 17 per cent of the cases. The average mortality rate for the first 12 surgeons is 4.6 per cent, as compared to the 17 per cent of the last operator. One can thus readily see how the statistics of one such surgeon can alter unfavorably the record for a whole institution.

THE CARE OF SURGICAL DIABETIC PATIENTS.—*The Rôle of the Liver:* If a clear understanding is to be had of the chemical changes that occur following an operation upon a diabetic patient, attention must be focused on the liver. The liver is a storehouse for glycogen which may be drawn upon in time of need. This organ does not contain the entire bodily supply of glycogen, for

about two-thirds of it is stored in the muscles (Chart 4). That in the liver, however, represents the portion easily available for use by the body.

The liver is concerned in the metabolism of sugar, protein, and fat. Its function is to make constantly available, in ample quantity, food for the body in a utilizable form. This availability must be independent of the rate of consumption and combustion of ingested food. Thus the liver has to store carbohydrates and convert other substances into glucose, when needed, in order to regulate the concentration of sugar in the blood. If this function of the liver fails, either hyperglycemia or hypoglycemia is the result. The liver also stores protein, and acts on amino-acids to form urea. Fat, too, is stored in the liver, sometimes to the extent of 40 per cent of the weight of this organ. The quantities of fat and glycogen in the liver bear a reciprocal relation to each other.

In addition to these metabolic functions, the liver regulates the formation of bile acids which are important in the absorption of fat and possibly of certain vitamins; its stellate cells remove bacteria from the blood stream; it destroys certain poisons, it regulates the normal process of coagulation of the blood; and it has a part in the maintenance of fluid volume.

It is easy to see how important the function of the liver is to a diabetic patient who must have an operation. The patient must receive carbohydrate, if the function of the liver is to be supported, and insulin must be taken if the carbohydrates are to be properly utilized. The surgeon must bear these facts in mind when he operates upon a diabetic patient, in order to disturb as little as possible the normal function of the liver. The type of anesthesia is extremely important in this regard. Chloroform may cause severe and possibly fatal hepatic injury, and should never be used in a diabetic patient. Ether, by reducing the store of glycogen in the liver, results in hyperglycemia which is directly proportional to the degree of narcosis[62] (Chart 5). Ether anesthesia also decreases the secretion of bile and depresses the formation of urea and causes an increase in the quantity of fat in the blood. If ether anesthesia has to be used in a diabetic patient, these facts must be taken into account, and measures must be instituted to combat them. The patient should go to operation with a good supply of glycogen in the liver, and should be protected afterwards from dehydration, hyperglycemia and acidosis.

A Special Diagnostic Problem.—The diagnosis of conditions which require surgery in the diabetic patient does not offer any special difficulty, except in the case of symptoms of an acute abdominal inflammation. In such instances, the differentiation between diabetic acidosis and acute appendicitis must be made. The importance of this differentiation is obvious, for to subject a patient with acidosis to an operation needlessly is an extremely hazardous procedure. In Table X are summarized the findings in both conditions, and about the only point of difference is that in acute appendicitis the pain precedes the vomiting, whereas in acidosis the vomiting precedes the pain.

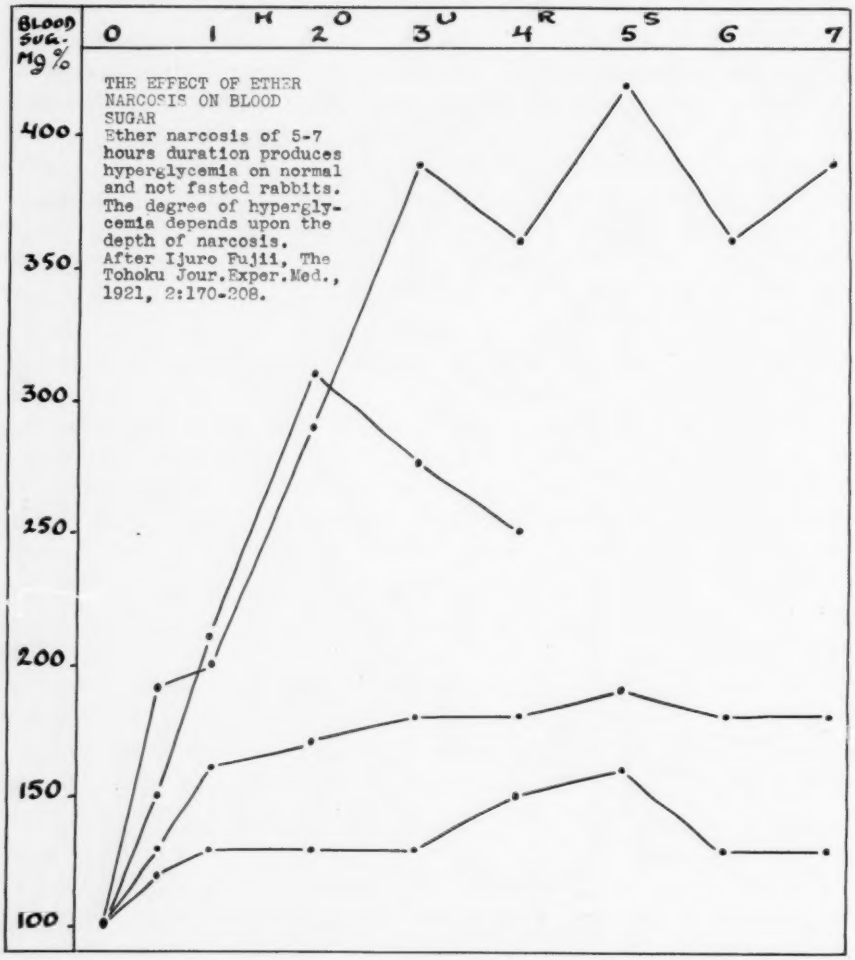

CHART 5.—Ordinates: Blood sugar. Abscissas: Hours. The effect of ether narcosis on the level of the blood sugar. (After experimental studies on rabbits by Ijuro Fujii. Tohaku Jour. Exper. Med., 2:170–208, 1921.)

TABLE X

DIFFERENTIATION BETWEEN DIABETIC ACIDOSIS AND ACUTE APPENDICITIS

Symptoms	Acidosis	Appendicitis
Vomiting	Precedes onset of pain.	Follows pain.
Fever	May or may not be present.	May or may not be present.
Leukocytosis	Usually high from dehydration and concentration of blood.	Usually high and may be significant.
Pain	Present.	Present.

This makes the problem sound quite simple, but such is not the case. In some instances, the patient's notion of the sequence of events is quite hazy, and it is difficult to get an accurate history. Much experience in the handling of diabetic patients usually is necessary before one may have complete assurance in the diagnosis of diabetic acidosis.

The doctor's responsibility, in such instances, is very great, for if operation is not performed in case of acute infection, the patient may have a ruptured appendix and peritonitis, and if operation is performed in an instance of acidosis, the patient is quite likely not to survive the shock. The best thing to do, in my opinion, is to give intravenously 500 cc. of a 10 per cent solution of glucose containing 20 to 40 units of insulin. If, within an hour or two, the symptoms are not relieved, they are most probably due to appendicitis, and the patient should be operated upon. It is usually safe to defer the operation for an hour, and this wait may be responsible for saving the patient's life.

The Preparation of the Patient for Surgery.—We have already seen that, if surgical results are to be good, and the risk of operation decreased in diabetic patients, the metabolic disorder must be taken into account every step of the way, and must be controlled as rigidly as possible if disaster is to be avoided.

In the preparation of diabetic patients for operation, the measures used have to be adjusted to the emergency or urgency of the situation. In case of an emergency operation, there naturally is no time for any deliberative or systematic study of the patient's condition. Even so, usually 30 to 60 minutes elapse from the time the patient enters the hospital until he appears on the operating table. This affords ample time for a urine analysis and an estimation of the blood sugar, which requires but 25 to 30 minutes. If the level of the blood sugar is high, the patient receives 20 units of insulin before the operation is begun.

When there is no immediate hurry about the operation, a thorough study of the patient can be made. It is possible to get the diabetic condition under control and to determine the patient's individual sensitivity to insulin. The diabetes is considered well controlled when the 24-hour sugar output is below 10 Gm. The variations in utilization of insulin are determined by the level of the blood sugar before breakfast, lunch and dinner. These indicate how the insulin dosage should be distributed throughout the day. Patients are no longer starved before an operation. They usually receive from 160 to 200 Gm. of carbohydrate, 70 to 100 Gm. of protein, and enough fat to make 1,800 to 2,200 calories, according to the individual needs. In patients with gallbladder disease, the fat naturally is kept to a minimum. The study made by the internist is directed toward finding out just what the dosage and distribution of insulin should be to enable the patient to utilize such a diet.

One blood sugar determination is practically worthless as a guide to a diabetic patient's condition. The blood sugar often fluctuates so much during the day that a single determination may be very misleading. It is not neces-

sary that operation be deferred until all three daily levels of blood sugar are exactly normal. If the patient's urine is sugar-free, and the level of the blood sugar below 200 mg. per cent, the operation can be performed with safety, provided the proper control is maintained. The important thing is to know just how much insulin the patient needs.

The morning of the operation, the patient receives his regular morning dose of insulin, a glass of orange juice, and a cup of coffee, at least two hours before the operation is to be performed. This helps to stock the liver with glycogen, and the patient does not feel so worn-out and hungry.

Protamine insulin can be used in surgical cases, although I prefer to use regular insulin during the preoperative and immediate postoperative periods. There is greater safety with small, frequent doses of insulin, than with one large dose of protamine insulin. The latter can be resumed during convalescence, when all emergency has passed.

TABLE XI

EFFECTS OF ANESTHESIA

Type	Effect
Local—procain	Least effect on insulin activity.
Barbital derivatives—sodium epival	Least reduction of liver glycogen.
Spinal—procain	Reduction of glycogen in voluntary muscle and heart.
Gas—nitrous oxide, ethylene, cyclopropane	Increase of lactic acid inhibits formation of glycogen in muscle.
Ether	Production of lactic and phosphoric acids in muscle augments acidosis.

Anesthesia.—The importance of the choice of anesthetic for a diabetic person has already been mentioned, in connection with its effect on hepatic function. Chloroform, because of its hazardous effects, has not been used in this country for about 30 years. Ether has many disadvantages, although with the proper precautions it can be used satisfactorily. This anesthetic is used largely at the Mayo Clinic, where surgical results are so excellent. If local or spinal anesthesia can not be employed, nitrous oxide, ethylene, and cyclopropane are the anesthetics of choice. The effects of these various anesthetic agents are summarized in Table XI. In general, the deeper the narcosis produced by an anesthetic, the greater the inhibition of oxidation of glucose and lactic acid in the brain. Chart 6 shows the increase in blood sugar in a series of diabetic patients as determined by studies immediately before and after operation. The greatest increase occurred in patients who were anesthetized with ether.

Postoperative Care.—In the case of the diabetic patient who has been subjected to an emergency operation, the study must be continued immediately following operation. Just after he has returned from the operating

room, another blood sugar estimation is made. At the same time 20 units of insulin are administered, with hypodermoclysis of a normal solution of sodium chloride and 5 per cent glucose. If indicated by the patient's condition, 500 cc. of a 10 per cent solution of glucose may be given intravenously. The level of the blood sugar is determined at two-hour intervals for the next six to eight hours, and then three times a day for the next two days. This keeps the physician informed regarding the patient's condition, and

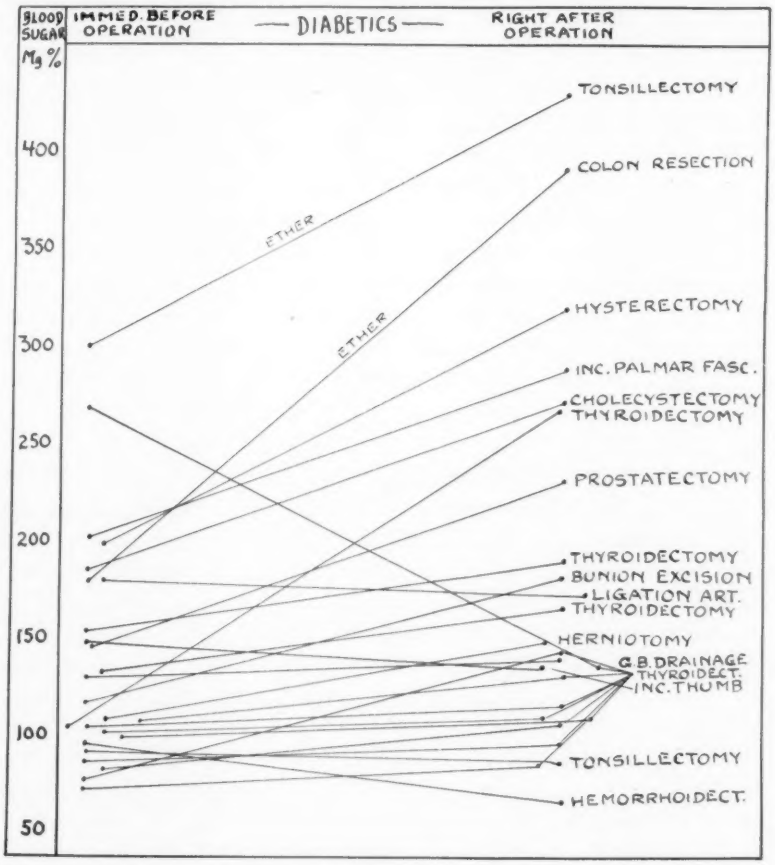

CHART 6.—Ordinates: Blood sugar. Abscissas: Effect pre- and postoperative. The effect of anesthesia on the level of blood sugar.

averts serious fluctuations in the blood sugar level. If it is impossible to check the blood sugar in this way, urine estimations must be made frequently, but the sugar in the blood is an infinitely better guide to the patient's condition. It must be remembered that acidosis is much more serious than large quantities of sugar in the urine.

The treatment in cases studied adequately before operation is much the same afterwards as that of the emergency cases. The administration of salt solution and glucose by hypodermoclysis or by vein, and sufficient insulin to

keep the blood sugar under control, with repeated checks of the blood are carried out. Within 24 to 48 hours, the emergency has usually passed, and the patient can safely be returned to his usual regimen.

Postoperative Complications.—*Intravenous Injection of Glucose.*—The use of glucose and salt solutions is a common procedure in caring for non-diabetic patients after operation, both in preventing and combating post-operative complications. It has been found that the same measure can be employed in diabetic patients provided sufficient insulin is given to allow the patient to utilize the glucose. This has been recommended by numerous authorities, including Thalheimer,[63] Fisher[64, 65, 66] Ringer,[67] Ginsberg,[68] and Levy.[69] Before the advent of insulin, this protective measure could not be used in diabetic patients, for any addition of glucose to the already increased quantity of sugar in the blood would have been dangerous. But now, if the proper quantity of insulin is added to the glucose-saline solution, the diabetic patient is protected from excessive hyperglycemia.[72] Table XII shows a summary of the fluctuations in blood sugar following intravenous injections of glucose solution in 54 patients with diabetes, who either had had an operation, or were suffering from diabetic acidosis. In the latter condition, the intravenous injection of glucose and insulin is especially valuable in combating the acidosis and increasing the excretion of ketones in the urine, and in augmenting the supply of glycogen in the liver. About two or three hours after glucose solution has been given, the patient's blood sugar should be checked, when more insulin can be supplied, if needed.

Glucose solutions are indicated in the following postoperative conditions: (1) After an operation of long duration; (2) when a large quantity of anesthetic has been used; (3) as a temporary measure before transfusion after profuse loss of blood; (4) in the event of possibility of severe surgical shock; (5) whenever there is the slightest danger of postoperative peritonitis.

Blood Transfusions.—Blood transfusion is perhaps the most helpful single measure available for combating postoperative complications. Transfusions are indicated in the following instances: (1) After profuse hemorrhage with reduction of blood volume; (2) in the presence of infections; and (3) in all cases which present a poor surgical risk, either because of the condition of the patient, or the extensive nature of the operation.

In administering a transfusion to a diabetic patient, it is well to remember, as Staub[70] has pointed out, that the blood of the donor has an action resembling that of insulin if he has eaten a heavy carbohydrate meal from four to seven hours previously.

Fever.—An increase in temperature always means increased metabolism. The fever in a diabetic patient may be the result either of toxemia or infection, and it is important to differentiate these two conditions.

When fever is present before an operation, a blood culture should be made. If the culture is positive, the patient, of course, should not be operated upon immediately but an attempt should be made to rid him first of the septicemia. If fever continues after the operation in a patient whose blood

culture was negative before, the culture should be repeated three days after the operation.

TABLE XII

CHANGES IN BLOOD SUGAR LEVELS AFTER INTRAVENOUS INJECTION OF GLUCOSE IN FIFTY-FOUR CASES

Case	Fall (Mg. per Hour)	Rise (Mg. per Hour)	Case	Fall (Mg. per Hour)	Rise (Mg. per Hour)
1	22	—	28	—	22
2	24	—	29	—	14
3	60	—	30	28	—
4	33	—	31	25	—
5	19	—	32	11	—
6	38	—	33	10	—
7	28	—	34	8	—
8	34	—	35	14	—
9	10	—	36	208	—
10	26	—	37	6	—
11	47	—	38	3	—
12	—	38	39	—	5
13	—	18	40	4	—
14	39	—	41	4	—
15	58	—	42	9	—
16	24	—	43	18	—
17	18	—	44	22	—
18	—	—	45	—	0.3
19	—	—	46	38	—
20	28	—	47	50	—
21	34	—	48	24	—
22	10	—	49	16	—
23	26	—	50	22	—
24	47	—	51	28	—
25	—	38	52	61	—
26	—	20	53	33	—
27	1.8	—	54	19	—

Fall—44 cases (81.5%)—Average 29.3 mg.
Rise— 8 cases (14.8%)—Average 19.3 mg.
No change—2 cases (3.7%)

In the toxemia resulting from infection, the patient often suffers from anorexia, and hence the intake of food is diminished. Nausea and vomiting may make it impossible for the patient to take any food or liquids. In such instances, with increased metabolism from the fever and little or no food supply, protein and fat catabolism are increased. This means production of urea nitrogen from the protein and of ketone bodies from the fat. The already impaired glycogen reserve of a diabetic patient is depleted after several days of fever, so that there is insufficient carbohydrate to aid in the complete

oxidation of the fat. Hence it is imperative that more carbohydrate be supplied, which is accomplished by the intravenous injection of glucose and sodium chloride solutions, in conjunction with the proper quantity of insulin.

Unconsciousness.—When a diabetic patient becomes unconscious after operation, it is important to differentiate between surgical shock, diabetic coma, hypoglycemia and alkalosis. In this differentiation, the history is of extreme importance, as well as the blood chemical determinations. Once the diagnosis has been made, the remedy is obvious (Table XIII).

TABLE XIII

DIFFERENTIATION OF POSTOPERATIVE COMPLICATIONS IN A DIABETIC PATIENT

Findings	Surgical Shock	Diabetic Coma	Hypoglycemia	Alkalosis
Unconsciousness	Present.	Present.	Present.	Present.
Temperature	Low.	Subnormal.		
Pulse rate	High.			
Respiration	Increased.	Kussmaul. Acetone breath.	Normal.	
Urine analysis		Sugar and acetone present.		
Blood chemistry		Sugar high; CO_2 usually below 20.	Sugar low.	
Perspiration			Profuse.	
Dehydration		Present.		
Convulsions				Present.
Tetany				Present.
History	Injury or operation.	Infection or lapse of diet.	Insulin injection.	Alkalies in large quantity.
Miscellaneous	Capillary distention; dilatation of splanchnic vessels; toxemia.	Soft eyeballs, low spinal pressure.	Strabismus at times.	

The patient suffering from surgical shock should receive glucose and insulin intravenously, and external heat should be applied.

For the treatment of diabetic coma, large doses of insulin, saline solution by hypodermoclysis, glucose solution by vein, external heat and gastric lavage and enemata are used. In the presence of acidosis, gastric lavage is an extremely important measure. In one instance in my experience, the patient died because of failure to carry out this measure. It was one of those

cases in which the differentiation of acidosis and appendicitis was vital. The patient was suffering from acidosis which was brought under control by the use of insulin, glucose and salt, but the patient died. The autopsy showed that he did not die from cardiac failure, but from respiratory failure due to regurgitation of gastric contents into the trachea, and consequent filling of the lungs. Since this experience, I have never failed to stress the fact that gastric lavage is essential in the treatment of diabetic acidosis.

When a patient is suffering from insulin shock or hypoglycemia, a 50 per cent solution of glucose should be given intravenously.

In the case of alkalosis, sodium chloride solution either intravenously or by hypodermoclysis should be given.

Renal Insufficiency.—The accumulation of waste products in the blood, as shown by high levels of urea, uric acid, and creatinin may result from anhydremia as well as from actual renal damage, in a diabetic patient. Unless there is considerable edema, infusions of sodium chloride solution (2 to 3 liters) containing glucose, or along with glucose solution administered intravenously, present the best method of treatment. At times, salt solutions containing 5 per cent glucose may be given by proctoclysis. Unless there is severe renal damage, administration of fluids tends to reestablish the normal status.

The use of Fischer's solution is helpful when there is marked depression of renal function. In 1931, I[71] reported the case of a man, age 26, who had acidosis and extreme oliguria. The kidney function was almost completely absent, as shown by no excretion following injection of phenolphthalein, and high levels of urea, uric acid and creatinin. This condition continued for five days, despite large doses of insulin (200 units a day). On the fifth day I gave him 500 cc. of Fisher's solution intravenously, and the urine output increased to more than six liters, after having been only a few hundred cubic centimeters daily. The urea, uric acid, and creatinin returned to normal levels, and the kidney function, as determined by the phenolsulphonphthalein test, was 70 per cent in two hours. From this and other experiences, I feel that Fisher's solution has a place in the treatment of cases of this type.

Anoxemia.—Anoxemia is a rather common surgical complication, especially in cases in which prolonged anesthesia has been required. The clinical signs of this condition include excitability, stimulation, headache, rapid pulse and a dusky appearance of the nails. These symptoms appear before the patient becomes frankly cyanotic. Increasing the patient's supply of oxygen by means of the oxygen tent is the treatment for this condition. The oxygen tent should be applied before the patient becomes actually cyanotic, and the reasons for its use should be explained to him, in order to secure his cooperation. A supply of four to five liters of oxygen each minute is usually administered, although higher concentrations which furnish as much as 15 liters per minute may be used.

It is well to use the oxygen tent as a prophylactic measure in patients who have had prolonged general anesthesia. The patient should receive inhalations of 5 per cent carbon dioxide with 95 per cent oxygen, for 15 to 20 min-

utes three times a day for three or more days after operation. This measure aids expansion of the lungs, insures a better aerating surface, and prevents atelectasis, and hence is prophylaxis against postoperative pneumonia.

SUMMARY AND CONCLUSIONS

Since the use of insulin in the care of diabetic patients, the surgical mortality rates in this type of case have decreased tremendously. An average of a series of 1,767 cases reported before the advent of insulin showed a mortality rate of 20.6 per cent, while in 9,513 cases reported since 1923, the mortality has been only 6.7 per cent. There are still tremendous variations in the results reported. These range from 1.2 to 68 per cent.

Surgery in diabetic patients carries a greater than normal risk, not because of the diabetes *per se*, but because of obesity, arteriosclerosis, advanced age, and the dangers of infection.

Cholecystitis is common among diabetic patients, and the removal of the gallbladder usually improves the diabetic condition.

Surgery of the extremities for gangrene is a special problem encountered in diabetes. The best treatment for gangrene is prevention, because the mortality rates in this type of operation are necessarily high, owing to the advanced age of the patients and the shock occasioned by amputation.

The proper care of a diabetic patient who has an operation demands the combined services of an internist and surgeon who are interested in the disease. The best results are obtained where there is the best team work.

A proper understanding of the function of the liver is necessary to provide the proper precautions for the diabetic patient who undergoes operation.

The most important diagnostic problems encountered in connection with surgery on diabetic patients are: (1) The differentiation between acute appendicitis and diabetic acidosis; and (2) the proper diagnosis of unconsciousness which may appear following an operation. The latter may be caused by surgical shock, diabetic coma, hypoglycemia or alkalosis. The history and blood chemistry findings are important in making this differentiation.

Except in situations that present an emergency, a diabetic patient should be subjected to thorough study before any surgical procedure is attempted. The proper dosage and distribution of insulin must be determined, if the diabetic condition is to be kept under control satisfactorily after the operation.

The choice of anesthesia is very important. Chloroform should never be used; ether has a great many hazards. The anesthetics of choice, when local or spinal anesthesia can not be used, are nitrous oxide, ethylene, and cyclopropane.

After an operation, the condition of the diabetic patient must be followed most carefully, with repeated determinations of the blood sugar, and adjustment of the insulin dosage, so as to prevent both hyperglycemia and hypoglycemia. Glucose intravenous solutions can be used, provided they are accompanied by appropriate doses of insulin.

Blood transfusions are of great help in preventing and combating postoperative complications.

Fever and anorexia bring about metabolic changes, with dehydration, accumulation of waste products, and hyperglycemia, which can be corrected only by the use of intravenous solutions of salt and glucose and insulin.

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STRANGULATED LITTRÉ'S FEMORAL HERNIA WITH SPONTANEOUS FECAL FISTULA

CASE REPORT WITH A REVIEW OF THE LITERATURE

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ALEXIS LITTRÉ,[1] in 1700, described three cases of hernia in which an intestinal diverticulum alone was strangulated. It was his belief that the diverticula were the result of traction on a portion of bowel in the hernia, a condition now associated with the name of Richter.[2] There is no proof that this was not the case.

Johann Meckel,[3] in 1810, over 100 years later, first classified the different types of intestinal diverticula. His name is now associated specifically with that diverticulum which is derived from an incompletely obliterated vitelline duct.

According to Thompson,[4] Meckel's diverticula in the vast majority of cases are found within the terminal four feet of the ileum; their size varies greatly, the average being about one inch in length with a fairly broad base. He groups the anatomic types most commonly seen as:

"1. The typical diverticulum given off from the antimesenteric side of the ileum, lying free in the peritoneal cavity, and presenting a closed distal extremity (82.5 per cent).

"2. Partial obliteration with a fibrous band running from the tip of the diverticulum to the umbilicus or to some adjacent structure (10 per cent).

"3. Umbilical fistula (6 per cent).

"4. The giant diverticulum of bizarre form or shape, sometimes coming off from the mesenteric side of the ileum and developing between the folds of the mesentery (0.5 per cent).

"5. The umbilical polyp, either attached to the remains of the omphalomesenteric duct inside the abdomen, or entirely cut off from internal connections (0.5 per cent).

"6. The simple intramesenteric variety (0.5 per cent)."

Obviously from the standpoint of both occurrence and anatomy, the diverticulum falling into Thompson's first group is the only one likely to be found in an inguinal or a femoral hernia. The intramesenteric diverticulum of large dimensions in group 4 has, by many, been considered a reduplication of the ileum.

It is through common usage that the title of Littré's hernia is applied only if the diverticulum is of Meckel's type, and is the sole occupant of the hernial sac.

Submitted for publication January 11, 1938.

Mason[5] notes the postulates expressed by Littré, who ascribed his difficulty in diagnosing his cases to the fact that the constricting force, falling on the pedicle of the diverticulum, did not interrupt the continuity of the lumen of the gut. The following are Littré's own rules as transcribed by Mason:

"The diagnostic signs, making this type of hernia recognizable before the operation, are:

"1. The patient goes to stool during the whole course of the illness as, the intestinal canal being uninterrupted, the excrements are at perfect liberty to pass from one end to the other.

"2. The patient has no hiccough, or very occasionally.

"3. He does not vomit, at least by comparison less frequently than in ordinary herniae. The vomitus is never fecal matter.

"4. The patient's belly is never fat, stretched or full of wind as in ordinary herniae.

"5. The tumor in the groin is formed more slowly and never becomes so large.

"6. The inflammation, fever, pain or other symptoms which may accompany this peculiar kind of hernia, are less severe and take longer to manifest themselves than in other herniae.

"The diagnostic signs which make this particular hernia recognizable during the operation are:

"1. In ordinary cases of hernia, the entire circumference of the intestinal body is engaged in the hernial sac. In this hernia there is only one part in the sac.

"2. The portion of the intestine which forms an ordinary hernia is found doubled in the shape of an arc in the sac. In this particular kind (which concerns us), this portion is single, situated perpendicularly and terminated by a very distinct end.

"3. An ordinary hernia is often formed by intestine and omentum together. This particular kind is always made by the intestine alone."

Such instructions, although formulated over two centuries ago, require today little, if any, correction or amplification.

Friedman[6] states that death is the inevitable fate of the patient with a strangulated hernia, unless the resulting obstruction is relieved by operative interference, spontaneous reduction of the hernia or the formation of an external fecal fistula. He further states: "The pathologic changes taking place in the formation of a fecal fistula are in the beginning like those of any strangulated hernia: first, there is an exudation of a bloody fluid into the hernial sac, and with impairment of integrity of the bowel, infection of the fluid. As the sac wall becomes infected and edematous, the bowel perforates into, and then through the sac, thereby involving the external hernial coverings. Infection and necrosis then spread rapidly through the subcutaneous tissues, and finally rupture occurs externally through the skin, forming an external fecal fistula."

Watson[7] states that in Littré's, as in appendiceal hernia, inflammation is

much more frequent than strangulation; when so-called "strangulation" occurs it is nearly always secondary to the inflammation and infection. True strangulation of a Meckel's diverticulum is rare. Sometimes it is impossible to determine whether inflammation or strangulation occurred first. With reference to location he says: "Strangulation of the isolated hernia of Meckel's diverticulum is more frequent in femoral than in inguinal hernia."

Appended is a report of a case of spontaneous fecal fistula resulting from a strangulated Littré's femoral hernia, which was observed and operated upon at the Vanderbilt University Hospital:

Case Report.—A. S., an unmarried white female, age 49, first came under the observation of the Medical Service March 30, 1935. She was treated for idiopathic migraine. Routine examination disclosed no suggestion of hernia. On November 29, 1935, when next seen, she gave a history of having had, four days previously, colicky pains in the lower midabdomen, followed shortly by the appearance of a swelling in the right groin. There was no nausea, emesis or obstipation.

Physical Examination disclosed a hard mass in the right groin over which the skin was reddened and slightly warmer than the surrounding region. There were no other enlargements in the glandular areas or open lesions on the lower extremities. Rectal and pelvic examinations revealed nothing abnormal. Leukocytes, 6,550. The impression conveyed at this time was that of an inguinal adenitis of unknown origin, and the patient was sent home to bed and instructed to use alternating hot and cold packs to the groin. On December 13, 1935, two weeks later, the only noticeable change was a decrease in redness of the skin.

On December 27, 1935, examination revealed a draining sinus at the site of the mass in the right groin, which the patient said had occurred nine days previously. She was referred to the Surgical Out-Patient Service where a hernia was suspected and, with the history of a large amount of green drainage increasing with ingestion of food, fecal fistula was diagnosed.

On January 2, 1936, the patient was admitted to the Surgical Ward where additional questioning revealed that six weeks ago, after going two days without a stool, she was seized with colicky pains which lasted 24 hours, but were not accompanied by nausea or vomiting. She took salts and had a stool the same night and the next morning. During the day of colic, the mass in the right groin had appeared and become as large as a lemon and gurgling was noticed in this region.

Physical Examination revealed a white female rather thin and drawn but not dehydrated. The abdomen was neither tender nor distended. There was borborygmus audible, but no visible peristalsis. In the right groin there was a small reddened, slightly tender, fluctuant mass about 6 cm. in diameter lying immediately over the inguinal ligament. In the center of this mass there was a peaked crater from which thin greenish material and a few small bubbles were expressed. On vaginal examination, the introitus admitted only one finger. There was a fulness in the right fornix, pressure upon which did not increase the flow from the sinus in the groin. Temperature was 99.6° F. Leukocytes, 5,600. Tests for bile and tubercle bacilli in the sinus drainage were negative. Carmine taken by mouth failed to pass in recognizable quantities from the sinus, a biopsy from which showed only granulation tissue. *Impression* at this time was: Fecal fistula resulting from perforation of a strangulated Richter's hernia in the right femoral region.

On the fifth day after admission, with the idea that closure might occur spontaneously, the patient was discharged and told to report to the Surgical Out-Patient Service. *Roentgenologic Examination* of the gastro-intestinal tract showed: "Esophagus, stomach and duodenum are normal. On the five-hour examination, the terminal ileum is shown filled and lying beneath the sinus. At six and twenty-four hours no portion of the large

bowel could be demonstrated communicating with the draining sinus. The cecum and appendix lie some distance away from the sinus. An irregular calcification overlying the right wing of the sacrum was seen. Fluoroscopic examination of the dressing over the sinus shows a radiopaque material, probably barium."

Operation.—January 22, 1937, by Dr. Barney Brooks: "An incision to the right of the midline below the umbilicus was made. On entering the abdominal cavity, a characteristic Meckel's diverticulum, the tip of which was buried in the right femoral canal, was found. Attempt was made to dislocate the tip of the diverticulum from the femoral canal from within the peritoneal cavity. It was obvious, however, that this could not be safely done. Incision was, therefore made parallel to Poupart's ligament through the fistulous opening, dividing the ligament over the femoral canal. This permitted freeing the tip of the diverticulum which was then resected, the wound in the ileum being closed with inverting continuous catgut sutures. A very irregular partially calcified cystic tumor of the right ovary, densely adherent to the wall of the pelvis, was extirpated. The abdomen was closed with continuous catgut for the peritoneum, interrupted silk for the fascia, subcutaneous tissues and skin. The inguinal ligament was resutured and the incision over it was loosely closed. A small rubber tissue drain was left in this wound. Because of the existing infection, no attempt was made to repair the hernia at this time."

Pathologic Examination showed the diverticulum to be 4 cm. long and 3 cm. wide at the base. There was a perforation at the tip. There was no evidence of gangrene at the time of operation. No gastric mucosa was found in the diverticulum.

The patient's recovery was uneventful and she was discharged on the fifteenth postoperative day. The inguinal wound was entirely healed one week later.

On April 8, 1937, the patient was readmitted for a repair of a right femoral hernia which was easily reducible but the source of some discomfort. A radical repair was accomplished by Dr. Barney Brooks. Convalesence was uneventful. The patient has been followed in the Out-Patient Service and has, apparently, remained cured.

Discussion.—Of 1,334 strangulated inguinal and femoral herniae, collected by Frackau,[8] 654 were inguinal, of which 89 per cent occurred in males and 11 per cent in females; 680 were femoral, of which 21 per cent were in males and 79 per cent in females. Between September 15, 1925, and June 1, 1937, 16 cases of strangulated femoral hernia were observed in Vanderbilt University Hospital. Of these, seven were in males and nine in females.

In a series of 21,693 autopsies compiled by Pabst,[9] Meckel's diverticulum was found 285 times, or in 0.9 per cent of the postmortem examinations. Christopher[10] states that 0.8 per cent of 1,382 patients coming to autopsy at the Boston City Hospital as well as of 2,000 at the Johns Hopkins Hospital were found to have a Meckel's diverticulum. In 1,511 autopsies performed in the Vanderbilt University Hospital during the period 1928–1936 inclusive, a Meckel's diverticulum was found six times, or in 0.4 per cent.

According to Christopher, in 10,000 celiotomies studied by Balfour, a Meckel's diverticulum was found in 15 patients, an occurrence of 0.14 per cent. In approximately 3,600 celiotomies at the Vanderbilt University Hospital, a Meckel's diverticulum was found in eight patients, an incidence of 0.22 per cent.

In 600 cases of Meckel's diverticulum, collected by Forgue and Riche,[11] only 52, or 8.7 per cent, of the diverticula were found in herniae. In analyzing this collection of 680 cases of strangulated femoral herniae, Frackau[8] notes that a Meckel's diverticulum was found in only one hernia.

In a review of the literature, there were 32 instances in which a Meckel's diverticulum was found in a strangulated or incarcerated femoral hernia. The present case report brings the total to 33. The designations strangulated and incarcerated were not always in keeping with the description of the operative findings, so that, in the light of accepted definition, liberty has been taken to interpret them correctly. As a result of this correction, 24 of the 33 cases are accepted to be strangulated femoral herniae of Meckel's diverticulum. Table I shows the analysis of the data referable to these 24 cases.

TABLE I

ANALYSIS OF COLLECTED CASES OF FEMORAL HERNIA CONTAINING STRANGULATED MECKEL'S DIVERTICULA*

Case No.	Original Author	Date	Sex	Age	Vomiting	Obstipation	Perforated	Result
1	Hager	1884	F.	55	No	No	No	Recovered
2	Tilling	1701	F.	—	—	—	No	Died
3	Martin	1765	M.	40	Yes	Yes	Through skin	Died
4	Escher	1891	—	35	—	—	Through skin	Recovered
5	Minter	1835	F.	44	—	—	Into sac	Died
6	Busch	1884	M.	53	—	—	Into sac	Died
7	Riecke	1834	F.	50	Yes	Yes	No	Died
8	Ekehorn	1901	M.	38	No	No	No	Recovered
9	Taignon	1700	F.	60	—	No	Through skin	Recovered
10	Hasenhorhl	1773	F.	38	Yes	Yes	No	Died
11	Raesfeldt	1852	F.	30	Yes	Yes	No	Died
12	Howse	1874	M.	37	—	—	No	Died
13	Hofmokl	1885	F.	76	—	—	Through skin	Recovered
14	Dutil	1886	F.	56	Yes	No	Into sac	Died
15	Mugnai	1898	F.	40	—	—	No	—
16	Smith	1901	F.	34	Yes	No	No	Recovered
17	Hilgenreiner	1903	F.	74	No	No	Through skin	Recovered
18	Riviere	1907	M.	44	No	No	No	—
19	Harrington	1926	F.	55	—	—	No	Recovered
20	Sweet	1930	M.	72	No	No	No	Recovered
21	Sinclair	1922	F.	55	No	No	Into sac	Recovered
22	Donati	1931	M.	79	—	—	No	Recovered
23	Mason	1933	F.	—	No	No	No	Recovered
24	Author	1937	F.	49	No	No	Through skin	Recovered

* Strangulated by definition.

Cases 1 through 8 collected by Ekehorn.[12]
Cases 9 through 18 collected by Pabst.[9]
Cases 19 and 20 collected by Sweet.[13]
Cases 21 through 24 collected by author.

The author has been able to find records of only 23 cases of strangulated femoral hernia of Meckel's diverticulum in the literature from 1700 to the present time. Of these, seven, or 29 per cent, were in males, and 16, or 67 per cent, were in females. In one the sex was not recorded. The youngest patient was 30 and the oldest 79 years of age. In two cases the age was not noted. The age distribution showed six in the fourth decade, five in the fifth

decade, six in the sixth decade, one in the seventh and four in the eighth decade. The average age was 50 years.

Of the 14 cases in which information was available, six, or 43 per cent, had vomiting. Of the 15 cases in which obstipation was noted, it occurred only four times, or in 27 per cent.

Six cases perforated through the skin, forming external fecal fistulae. Of these only one, or 16.6 per cent, died. Of the four that perforated into but not through the sac, three, or 75 per cent, died.

All might be designated Littré's herniae except Case 12, which contained strangulated omentum in addition to the strangulated diverticulum, and Case 21, whose sac contained both a Richter's hernia of the ileum and a perforated Meckel's diverticulum. In Cases 3 and 4, ascaris worms were observed coming from the fistulous openings. In Case 4, the fistula healed spontaneously and the Meckel's diverticulum was discovered later when the persistent hernia was operated upon.

In analyzing the six cases in which a fecal fistula occurred spontaneously, it was found that one was in a male, four in females, and one in which the sex was not recorded. The ages of the patients were 35, 40, 49, 60, 74 and 76, the average being 56.

In one there was vomiting and in two cases there was no vomiting. No mention was made of this symptom in the other three cases. Obstipation was present in one patient, in three it was absent, and in the remaining two, no information was available. The patient who died was a male, age 40, who had both obstipation and vomiting. This patient was the only one, of this series of six, with spontaneous fecal fistula from strangulated Littré's femoral hernia, to have either obstipation or vomiting.

SUMMARY

(1) Littré's hernia has been defined.

(2) The symptoms and signs of Littré's hernia, as transcribed by Mason, are noted.

(3) A case of spontaneous fecal fistula from a strangulated Littré's femoral hernia is reported.

(4) A Meckel's diverticulum was found in 0.9 per cent of 21,693 autopsies, while in two groups of 1,382 and 2,000 postmortem examinations, the same structure was found in 0.8 per cent of the cases. In the Vanderbilt University Hospital, in six, or 0.4 per cent, of 1,511 autopsies a diverticulum was found.

(5) A review of the literature, from 1700 to the present time, revealed that, including the present case, 24 instances of strangulated hernia of a Meckel's diverticulum were reported.

(6) In six of the 24 cases of strangulated hernia of a Meckel's diverticulum, there occurred a spontaneous fecal fistula. In this group, only one patient died. In four instances in which there was a perforation into but not through the sac, three of the patients died.

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THE PERINEAL TESTIS

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INCIDENCE.—In 1786, John Hunter[6] described two cases of perineal testes. Curling gave the first detailed description of the condition, in 1841, and collected nine cases. In 1879, Annandale reported the first successful operative cure.

Weinberger,[14] in 1879, compiled 74 cases of perineal ectopy. Muschat,[10] in 1933, collected 23 more reports and added one of his own. Campbell, in 1936, stated that 99 cases have been recorded in the available literature and reported three personal cases. The fact that only slightly more than 100 cases of perineal testes have been recorded in the literature indicates the comparative rarity of the condition.

It is generally accepted that the incidence of an undescended testis is once in every 500 men. Godard found three perineal testes in 53 cases of imperfect descent. Burdick and Coley[1] did not encounter a perineal testis in 537 instances of cryptorchidism. Campbell[2] did not observe one instance in the records of 18,000 autopsies of males. He also states that there was not a single case recorded in 36,000 admissions to the Urologic Service of Bellevue Hospital, New York City. Eccles found five perineal testes in 936 instances of imperfect descent. Over a 17 year period, there occurred 15 cases among 737 imperfectly descended testes seen at the Hospital for the Ruptured and Crippled at Boston (Coley[3]). While rare, the perineal testis is more common than the pubopenile or femoral ectopies (McGregor[9]).

Etiology.—McGregor accounts for this failure of descent of a testis on an anatomic basis. He found that: "In the perineal region there exist on each side two ridges of fascia which separate three pouches. The perineoscrotal reduplication of Colles' fascia separates the scrotal from the superficial perineal pouch. This reduplication forms a smooth ridge. The fascia of Colles here doubles back on itself at an acute angle in the adult dependent scrotum and at a right-angle in the fetal scrotum. The testis or gubernaculum, having traversed what he calls the third inguinal ring, passes down the scrotal neck and arrives at this ridge. At the sixth month, there is a well marked scrotal pouch in the vast majority of cases. Should the fascial reduplication narrow or occlude the orifice, the testis cannot enter the scrotum and may pass posterior to it into the perineum."

Heredity has been considered a factor in the etiology; Godard mentioned a case where father and son both had a perineal testis.

Submitted for publication December 13, 1937.

Sonneland[13] believes that many perineal testes are traumatic rather than congenital in origin. That a scrotal or inguinal testis may be luxated to a perineal position is suggested by the anatomic studies of McGregor, but how often this actually occurs is unknown. Godard reported the case of a man, age 56, who wore a tight bandage over an interstitial type of ectopy which changed it to the perineal variety.

Complications.—One would expect the same complications to occur in the perineal as in the other forms of undescended testes. Franz reports an instance of epididymitis in a male, age 24, with a left perineal testis, but whether there is a greater predilection for the ectopic organ is unknown.

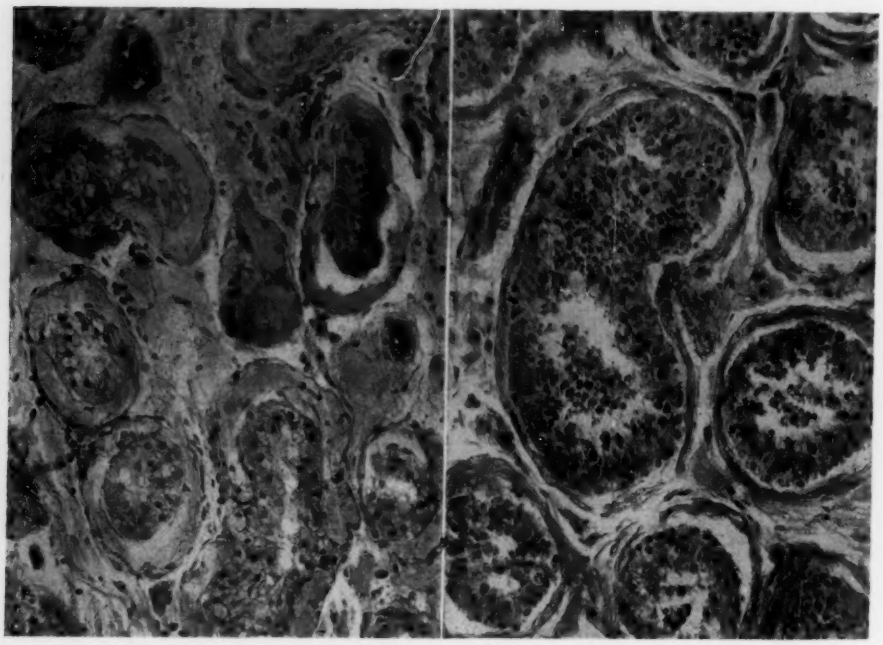

FIG. 1.—Case 1 (Path. No. A-36-2056): Left perineal testis in man, age 54. Photomicrograph showing marked degenerative changes in seminiferous tubules with hyalinization; increase in fibrous interstitial tissue. No spermatozoa (×150).

FIG. 2.—Case 1 (Path. No. A-36-2056): Right descended testis. Photomicrographs showing testis to be normal except for slight disorganization (×150).

No instance of malignancy of a perineal testis has been reported in the available literature, probably because too few cases of perineal ectopy have been reported.

Histology.—Sonneland, in 1924, could find no histologic study of a perineal testis. Even at the present time, no mention of the minute anatomy of such organs can be found in the available literature. McGregor states that the perineal testis is usually of normal size and development. This statement is surprising, knowing from clinical and experimental studies how atrophic the testis becomes when deprived of its scrotal environment. From a histologic point of view, the appended case reports are instructive:

Case 1.—No. UH 621277: R. P., age 54, was admitted to the University of Minnesota Hospitals October 9, 1936. He had been treated in the Out-Patient Clinics for a chronic duodenal ulcer, tabes dorsalis, and a neurogenic vesical dysfunction. He had been receiving antisyphilitic therapy, and had followed a medical regimen for the duodenal ulcer. Because of marked pyloric obstruction and epigastric pain, he was referred to the hospital, where a posterior gastro-enterostomy was performed, from which he died.

Physical Examination.—The patient had a perineal testis. He had no symptoms referable to this abnormality. The perineal testis was situated on the left side near the scrotal-thigh juncture, and could be pushed posterior to the scrotum near the median raphé and anteriorly in front of the pubic bone. It measured 3 by 2¼ by 2 cm. There was a left indirect inguinal hernia; the spermatic cord was not definitely felt on the left. The scrotum was atrophic on this side. The right testis was normal in size, shape and position and measured 4½ by 3 by 2 cm.

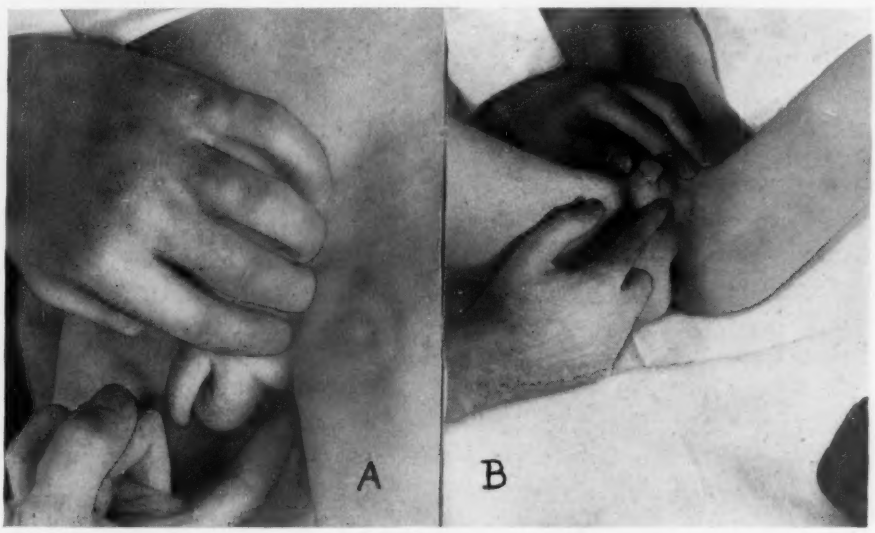

FIG. 3 A and B.—Case 2: Left perineal testis in boy, age six. The testis has been pushed up toward inguinal region. Note atrophic scrotum on left side.

Autopsy Report.—The right testicle weighed 23 Gm. and the left 8 Gm. The left testis was definitely atrophic in appearance. The relationship of the epididymis and testis was normal. The tunics of the ectopic gonad were thickened. Microscopically (Path. No. A-36-2056), the perineal testis showed marked degeneration of the seminiferous tubules; no spermatogenic cells were seen. There was an increase in the interstitial tissue (Fig. 1). The right testis was fairly normal in appearance except for some disorganization of the germinal epithelium probably the result of the patient's terminal illness (Fig. 2).

Case 2.—No. UH 632363: E. B., age six, was admitted to the Out-Patient Pediatric Clinic with a left indirect inguinal hernia and a left perineal testis. Past history was essentially negative except that the child had been operated upon at two weeks of age for pyloric stenosis (Rammstedt operation).

Physical Examination revealed that while the right testis was in the scrotum, the left testis lay under the skin in the perineum; it could, however, be pushed between the scrotum and thigh to the left inguinal ligament. The testes were the same size and measured 1¼ by 1 by 1 cm. The patient's mother said that at no time had there been symptoms referrable to the ectopic organ (Figs. 3A and B). The patient was referred to the hospital for a left orchiopexy.

Operation.—October 26, 1937: The procedure employed was Wangensteen's modification of the Keetley-Torek operation. A vaginal type of congenital hernia was present. A fibromuscular band of tissue about 4 cm. long (the gubernaculum) extended from the lowest portion of the hernial sac and testis and spread out into the fibrous tissue in the scrotal-thigh juncture. From the external ring the testis could be pushed over the inguinal ligament along the scrotal-thigh juncture almost posterior to the scrotum. The scrotal neck was stenotic and closed over by fibrous tissue. Definite evidence of reduplication of Colles' fascia in this region, as McGregor described, was not seen.

There was a slight separation of the testis and epididymis and an appendix testis was present. The ectopic testis measured 1 by 3/4 by 3/4 cm. The tunics were not thickened. A biopsy of the testis (Path. No. HO-37-3214) showed small seminiferous tubules separated by a loose connective tissue stroma. The lumina of the tubules were obliterated by two to three irregular layers of darkly staining epithelial cells. The whole appearance was that of a prepubertal testis, not unlike that which one would find in the normally descended testis of a boy of the same age (Fig. 4).

FIG. 4.—Case 2 (Path. No. HO-37-3214) Photomicrograph of a section of the perineal testis shown in Fig. 3. The appearance is not unlike that seen in normally descended prepubertal testes of patients of same age (×150).

Treatment.—The treatment of the perineal testis is surgical. While most patients with undescended testes may have the operation deferred until the ninth to eleventh years, patients with perineal testes probably should be operated upon earlier, as the chance of trauma to the ectopic gonad would seem to be greater. The use of gonadotropic hormone is not indicated, because further descent will not improve the aberrant position; the value of using this substance to increase the size of the prepubertal perineal testis may be questioned. The treatment of choice in this condition is orchiopexy.

SUMMARY

That the perineal testis is a rare anomaly is evident since only slightly more than 100 cases have been thus far reported. No mention of the histology of such organs has been found in the available literature.

Two cases of perineal testes are presented. A histologic study of these two testes revealed the usual picture incident to cryptorchidism. In the man, age 54, the perineal testis showed the atrophic changes commonly seen in old, untreated undescended testis; in the young boy, age six, the ectopic testis had

the appearance of a prepubertal gonad, indistinguishable from that of a normally descended testis in a patient of the same age.

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EFFECTS OF LIGATIONS ON NERVES OF THE EXTREMITIES

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IT HAS been shown in other papers that ligations of the limbs result in an instructive form of shock; and also that the resistance to local asphyxia is greater than is commonly supposed, since the limbs of animals can survive complete lack of circulation for at least 15 hours, and the same is presumably true for man. Granting a proper form of tourniquet applied without excessive tension, the danger of gangrene under ordinary surgical conditions is largely imaginary. Certain other sequelae are of surgical interest, however, particularly, the occasional paralyses or contractures. Only two possible causes for such lesions exist: namely, pressure in the zone of ligation, and asphyxia. Experimental observations favoring each of these causes will be discussed.

Trauma of Tourniquet.—(1) In rats, brief ligations of a hind leg for five to 20 minutes cause varying degrees of injury, the motor manifestations ranging from slight lameness to complete paralysis, while the responses to sensory stimuli indicate different grades of obtunded sensibility rather than anesthesia. The rabbit shows less effect than the rat, and the dog and cat are still more resistant, so that their legs can be ligated for several hours with comparatively slight nervous effects. Rather than to assume that the tissues of the larger species are less sensitive to asphyxia, it is more rational to consider that their tougher structure makes them more resistant to pressure of the tourniquet.

(2) As the ligations of the rat's leg are lengthened beyond 20 minutes, the nervous effects increase, so that after 40 minutes there is complete paralysis and anesthesia. There is no increase of degree when the time of ligation is increased to as long as ten hours, but there is a marked and progressive increase of duration. After the 40-minute ligation, the nerve functions may return within a day or two, but after the longest ligations the recovery is delayed for several weeks, as will be shown later. This recovery is plainly the result of regeneration of nerves, because its progress is traceable from above downward. If the nerves must regenerate after being killed by asphyxia, it is difficult to see why the process should be more rapid after a three-hour ligation than after a ten-hour ligation; but it is a reasonable assumption that more severe and prolonged damage will result in the zone of ligation after ten hours than after three hours. Similar results are found in the larger species.

(3) Comparatively brief ligations, from 15 minutes up to two hours, when suitably repeated over a series of days, increase both the degree and

Submitted for publication February 19, 1938.

the duration of the paralysis, which in some instances has taken as long as two months to clear up.

Asphyxia.—(1) When a small hole is dissected through the upper leg, so that one rubber ligature can be passed through on one side of the sciatic nerve, and another ligature on the other side of the leg, it is possible to ligate all structures of the leg except the nerve, and the usual paralysis is still obtained. A partial objection can still be made that the nerve is damaged by an inflammatory process.

(2) Ehrlich and Brieger obtained prolonged paralysis of the hind legs, bladder and rectum by clamping a rabbit's aorta just posterior to the renal arteries for 45 to 60 minutes. The writer has duplicated this experiment, but a simpler way of obtaining the same result is by binding a heavy rubber band tightly around the lower abdomen of a semi-anesthetized rat or rabbit. In a large number of such experiments performed upon rats, the more detailed findings were as follows: One hour is about the longest safe period; strong rats will often endure one and one-half hours, but two hours or longer cause rapid death from shock. The impairment of defecation may continue for a couple of weeks but is seldom dangerous; occasionally it is responsible for fatal fecal obstruction. The bladder paralysis, accompanied by prostatic swelling, results in the death of all male rats within about a week, from urinary retention, with accompanying hydro-ureter and hydronephrosis. Female rats, however, recover, and the paralytic urine retention and dribbling pass off in about two weeks. Other results are illustrated in the following summary of a typical protocol:

Experiment 1.—Ligation of a rat's abdomen for 45 minutes was followed by complete paralysis and anesthesia of rear parts, but within three hours sensation was again present in hind legs and tail. Perfect sensory function continued, but motor paralysis remained complete until curling movements of the tail (voluntary or reflex) were noticed on the fifteenth day. Four days later a very slight use of the hind legs began, and increased steadily to normal locomotion, ten days later (29 days after ligation).

In this experiment, the spinal cord is evidently protected against pressure by its bony encasement, and is nourished by its own blood vessels. Also, if the paraplegia were due to destruction of the cord, regeneration would be impossible. The conditions are still clearer when the paralysis results from ligation of the aorta alone. Therefore, it is positively demonstrated that paralysis can be produced in the rat's legs by 45 minutes of asphyxia, uncomplicated by any local traumatism.

It must be deduced from the above that paralyses due to destruction of nerves can be caused both by direct crushing and inflammation in the region of the tourniquet, and by asphyxia. It is possible for the direct tourniquet pressure to give rise to ulceration, necrosis, scarring and various permanent deformities, in all the animal species used. On the other hand, in hundreds of experiments performed for various purposes, there has never been a single instance of permanent damage when the paralysis was produced by asphyxia alone, without any local trauma. The animal experiments, therefore, indicate that asphyxial injury of nerves and also of the muscles (if not carried to the

point of gangrene) is always followed by complete recovery; that, therefore, the word "ischemic" is wrongly applied to permanent paralyses and contractures following the clinical use of the tourniquet; and that these effects are most probably attributable to direct trauma of the nerves and muscles under the tourniquet.

Influence of Tension and Temperature.—All the statements in this paper are based upon the use of a narrow rubber tourniquet, applied with just sufficient tension to stop the arterial blood flow. Obviously, excessive tightness of the ligature is a most provocative cause of damage to the nerves, vessels and all other tissues.

Loose, partial, or "venous" ligations, which impede the venous return while permitting arterial inflow, may produce great congestion and edema and some degree of subsequent arterial hyperemia, but they do not cause paralysis or anesthesia, even when prolonged to eight hours or repeated over a series of days.

The statements also apply to results obtained at comfortable room temperatures. All the effects of asphyxia, including the nerve degenerations, are greatly augmented or accelerated by heating the ligated part to febrile temperatures, and are likewise progressively retarded by cooling, down to a minimum close to 0° C., as described in other papers.[1] It also seems reasonably certain that the effects of direct pressure of the tourniquet upon nerves and other structures are increased by warmth and diminished by cold, though data have not been collected for positive proof.

Motor and Sensory Regeneration.—As above mentioned, large numbers of experiments in rats have uniformly shown that sensation suffers less from ligation than muscular power. Since the two kinds of nerve fibers supposedly do not differ in physical resistance, and since they sometimes run in the same nerve trunks, it seems necessary to explain the different behavior as a distinct difference in sensitiveness to asphyxia.

There is an equally distinct difference in the rates of regeneration. Special observations on several scores of rats yielded the appended data on the rate of recovery following different periods of asphyxia (Table I):

TABLE I

RATE OF RECOVERY FOLLOWING DIFFERENT PERIODS OF ASPHYXIA

Duration of Ligation	Results
¼ to 1 hour	Increasing impairment, up to complete paralysis and anesthesia, but usually passing off within a day or two
2 to 3 hours	Shortest recovery of sensation in 4 days; of muscular movement in 12 days. Latest recovery: Only partial return of sensation in 23 days with paralysis still complete
4 to 4½ hours	Recovery of sensation in 18 to 22 days; of muscular movement in 4 to 6 weeks
5 to 6½ hours	Recovery of sensation in 16 to 24 days; of muscular movement in 5 to 6 weeks
8 to 9 hours	Sensation evident in 3 to 4 weeks, but apparently blunted. Recovery of muscular movement in 7 to 8 weeks

Comparative Resistance of Nerve Fibers and Cells.—At the time of publishing (1919, 1922) the experiments with clamping of the pancreatic vessels, the writer[2] was only partially acquainted with the literature of asphyxial effects upon nerve cells, and, therefore, had some hopes of obtaining totally denervated organs by stopping the blood supply long enough for all nervous elements to degenerate while the glandular tissues survived. It was a surprise to find the numerous intrapancreatic ganglia in excellent condition microscopically after asphyxia for as long as two hours; the impression arrived at was that the nerve cells could survive fully as long without circulation as the epithelial cells. This observation has since been learned to be in harmony with those of earlier investigators.

The earliest tests (Mayer,[7] 1878) showed that brain functions could not be restored after the carotid and vertebral arteries had been clamped for ten minutes. Batelli[3] extended this time to 15 minutes in some instances, when the circulation was arrested at the heart or aorta. The findings of Stewart, Guthrie, Burns and Pike[11] were confirmatory. Others (Ehrlich and Brieger[5]; Spronck[10]; Sarbo[8]; Gomez and Pike[6]) proved that the small pyramidal cells of the cortex were the most sensitive, being killed in eight minutes, while the Purkinje cells break down after 13 minutes. The cells of the medulla require 20 to 30 minutes of anemia before the damage is irreparable. The cells of the spinal cord and spinal ganglia survive asphyxia up to 45 or possible to 60 minutes. The cervical ganglia (Tuckett,[12] Schroeder[9]) retain structure and function after more than 60 minutes, being more resistant than the cells of the central nervous system.

Cannon and Burket demonstrated that when the blood supply of portions of intestine is completely ligated off for six or seven hours, the ganglion cells of the myenteric plexus still retain normal microscopic appearance and functional capacity. They point out the importance of this remarkable resisting power in relation to hernia, intussusception and other accidents involving temporary anemia. If, instead of ligation, the anemia was produced by broad pressure between two plates of glass, the nerve cells could survive for only three and one-half hours, and, furthermore, the smooth muscle tissue suffered round cell infiltration and partial replacement by fibrous tissue. Whether the reason is because of the more complete pressing out of blood, as Cannon and Burket[4] seem to imply, or a displacement of lymph and tissue fluids, or direct injury of the cells by pressure, the use of glass plates seems to be comparable to the employment of wide tourniquets of any type. As mentioned elsewhere, the prevalent surgical practice of trying for a wide distribution of pressure is, according to experimental evidence, not as gentle and conservative of tissue vitality as has been supposed, but is actually more destructive than a narrow ligature, provided the pressure in each instance is just sufficient to stop the blood flow.

These results, showing no serious damage to ganglion cells after six or seven hours of ligation, may be compared with those previously described, in which motor and sensory paralysis of the limbs was obtained after much

shorter ligations. The comparison is best made with the experiments in which paralysis of the hind legs of rats and rabbits resulted from about an hour of stoppage of circulation in the abdominal aorta, so that any mechanical traumatism of the leg nerves by the tourniquet is excluded. The conclusion seems apparent that the peripheral nerves are more resistant to asphyxia than the cells of the central nervous system, but less resistant than sympathetic ganglion cells. Careful attention should be paid to possible differences between species before drawing such conclusions too positively. The temperature during ligation is also a most important factor. Since the myenteric plexus retains its function after the ligations mentioned, there must be a survival of the fibers as well as the ganglion cells. In the leg ligations, no anatomic studies have been made to determine whether the sympathetic fibers degenerate along with the motor and sensory fibers, in which case the prolonged hyperemia must be strictly paralytic in character; or whether all the sympathetic fibers survive, or only the vasoconstrictors degenerate, so that there may be a nervous element in the vasodilatation. There is a very obvious teleologic reason for the high resistance of peripheral ganglion cells, because of the chance of their being exposed to anemia for periods which would kill central nervous cells and because of the irreparable damage resulting from their loss. There is no such teleologic reason for resistance on the part of the fibers, because they can regenerate; but it is physiologically difficult to comprehend survival of the cell bodies under conditions which kill their neuraxes. If the contrast exists between the entire sympathetic neurone and the entire cerebral or spinal neurone, or between preganglionic and postganglionic fibers, there may be a useful experimental opportunity to free an organ from part or all of its innervation by means of suitable asphyxia. It may also be inquired whether the different resistance of central and peripheral nerve cells, or of motor, sensory and sympathetic nerves is connected with differences in the activity of their metabolism or with other causes. The entire question of differences in resistance to anemia is therefore interesting but unsettled.

CONCLUSIONS

(1) The nerve lesions resulting from ligation of limbs may be caused either by direct pressure of the tourniquet or by asphyxia. The experimental evidence suggests that permanent paralyses arise only from the former cause. It further suggests that wide pressure is more injurious than a narrow band.

(2) The duration of the nerve paralyses increases in proportion to the time of ligation, as illustrated by a schedule of the periods required for recovery in the legs of rats after graded periods of ligation.

(3) The tension of the tourniquet, and the temperature during ligation, are important factors in the after-effects.

(4) Motor and sensory nerves differ in their sensitiveness to asphyxia, in that the former suffer paralysis much more readily and also regenerate more slowly.

(5) These experiments, together with the existing literature, show that

peripheral ganglion cells are enormously more resistant than the fibers of cerebral or spinal nerves. Numerous details concerning the comparative resistance of various nerve cells and fibers are undecided.

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ACUTE HEMATOGENOUS BURSITIS

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Acute bursal infections of metastatic origin are rare complications that may arise in the course of, or as sequelae to, the acute infectious diseases, septicemias; or as secondary, metastatic lesions in pulmonary, otitic, upper respiratory, dental, or dermal suppuration.

The onset may be insidious or sudden, with chills, fever and prostration. The local lesion makes its presence known by localized pain over a joint, slight swelling, limitation of movement due to pain and muscle spasm. Before the inflammatory exudate is of sufficient amount to distend the sac, the condition may be mistaken for acute infectious arthritis, or osteomyelitis. As the disease progresses, however, the inflamed bursa may become clearly outlined and palpable. Undoubtedly, deep seated bursitis in any location is more often overlooked than recognized. A knowledge of the location, extent, and possible pathology of bursae may, in many cases of unyielding inflammation, explain the obscure pain about such regions as the hip, shoulder or knees. Bursitis should always be considered in deep seated abscesses of obscure origin, especially in the neighborhood of the buttock.

Metastatic bursal abscesses may occur at any age, but the disease is more common in adults. Purulent effusion in the subacromial bursae was observed by the writer in two infants suffering from gonococcus bacteriemia. Incision yielded pus which on culture showed the gonococcus.

Boissonas and Kummer[1] quote A. Martin who, in 1929, reported a number of cases of suppuration in the muscles, synovia, joints and bursae, following varicella. One case showed suppuration of the trochanteric bursa and one of the retro-olecranon bursa. Recovery occurred after incision and drainage.

J. M. Hitzrot[2] reported three cases of infectious, calcific subacromial bursitis. In one, a hemolytic Streptococcus, originating in a tooth, a sinus in another, and a hemolytic *Staphylococcus aureus* in an ulceration of the cervix, were recovered in the exudate evacuated at operation. Hitzrot observed another case of suppurative bursitis involving the bursa, over the coracoclavicular ligament, which appeared in a man three weeks after mastoidectomy secondary to pneumonia. Incision yielded pus, which on culture showed a Streptococcus.

B. S. Barnes[3] reported two cases of suppuration of the shoulder, one of these involving the subacromial bursae. The patient was a woman, age 35, who suffered from a Streptococcus septicemia, secondary to an induced abortion. During the course of her illness, the left shoulder became involved and

Submitted for publication January 22, 1938.

a large collection of pus was evacuated from the subacromial bursa. Blood and smear cultures showed the presence of hemolytic Streptococci.

Codman[4] considers acute suppurative subacromial bursitis a rare lesion. In 1,151 various shoulder lesions, he saw only one suppurating acute case from pathogenic bacteria. Even this case was doubtful, and was probably to be explained by contamination of the culture.

Weeks and Delpart[5] stress the importance of focal infection in cases of subacromial bursitis. Acute symptoms may occur after a period of rest and without immediate antecedent trauma.

In their cases, some upper respiratory infection, such as cold, influenza, or abscessed teeth, usually preceded onset of shoulder pain. They do not make any references to acute suppurative lesions in their communication.

L. Carp[6] reported eight cases of radiohumeral bursitis, but none of these was of the infectious type. One case was operated upon by Dr. S. Kleinberg. The bursal cyst contained a milky fluid, which on culture was negative. Microscopic examination revealed thickened inflammatory tissue, foreign body giant cells, and irregular deposits of calcareous material.

Lasher and Mathewson,[7] writing upon olecranon bursitis, state that frequently at the time of an injury superficial abrasions or lacerations of the skin occur. These afford a portal of entry for low grade infections, and the synovial fluid in the distended bursae becomes an excellent culture medium for the slow proliferation of invading organisms. The occurrence of osteomyelitis is almost an invariable complication when the bursa is distended with pus. The type of lesions these authors describe was due to local penetration of bacteria. Their cases were not of metastatic origin.

Six cases of metastatic bursal abscess form the basis of the present communication. The subacromial bursa was involved in four patients, the gluteal and prepatellar in two.

The disease occurred as a complication in two cases of acute mastoid suppuration, in two cases of pulmonary suppuration, and in one case of Staphylococcic septicemia, secondary to carbuncle. In one case of purulent subacromial bursitis, we did not ascertain the origin of the abscess. Blood cultures were positive in two patients. In the cases of otitic origin, smear studies of the discharge from the ear and evacuated bursal pus, similar organisms were isolated—pneumococcus Type 3, and hemolytic Streptococci. Patients with positive blood cultures revealed identical organisms in the bursal pus—hemolytic Streptococci and hemolytic *Staphylococcus aureus.*

Needling was employed in all cases as a diagnostic measure. This verified the diagnosis of abscess in all but the case of gluteal bursitis. In this case an early diagnosis was not made. Spontaneous rupture occurred six weeks after onset of the disease.

Suppurative Subacromial Bursitis

Case 1.—P. R., male, age 62, was admitted February 20, 1936, to Mt. Sinai Hospital, for treatment of acute mastoiditis of four weeks' duration. Roentgenologic ex-

amination revealed a cloudy mastoid with ill-defined and decalcified cellular structures. Temperature, 99.2° F.; blood pressure, 150/75. While the ear condition represented the major lesion, the patient had also complained of pain and stiffness of the left shoulder for the previous three weeks.

Physical Examination: The left ear revealed a profuse, yellow discharge, perforation of ear drum, and mastoid tenderness. Heart, lungs and abdomen were negative. The left shoulder joint was painful, tender and stiff. Movements were restricted by muscle spasm. No effusion was demonstrable in the joint or subacromial bursa.

Laboratory Data: Blood count: Hb. 92, R.B.C. 4,700,000; W.B.C. 12,300, large lymphocytes 26, transitionals 2. Urea nitrogen 23.3. Blood sugar 140. Urine: faint trace albumen, occasional W.B.C. and hyaline casts.

Operation.—February 20, 1936: Mastoidectomy was performed under general anesthesia. Extensive necrosis necessitated removal of considerable bone. During course of operation, the lateral sinus was accidentally opened, requiring packing to check the hemorrhage.

Postoperative Course: Five days after operation, the patient developed a chill; temperature rose to 103° F.; pain in the shoulder became accentuated; fluctuation over subacromial bursa was demonstrable. Roentgenologic examination revealed slight erosion of greater tuberosity and anatomic neck of humerus. Blood culture was negative. Diagnostic bursal tap yielded bloody pus. Under local anesthesia, a two inch, linear incision was made over the upper arm, the fibers of the deltoid muscle were separated, and a copious purulent collection in the subacromial bursa evacuated. Finger exploration failed to reveal any perforation in bursal floor. Smear and culture studies from ear and bursa revealed pneumococcus Type 3. Systemic and local symptoms promptly subsided following above procedure. Complete functional restoration of the involved shoulder was obtained in six weeks.

Case 2.—D. M., male, age 33, was admitted to Mt. Sinai Hospital November 16, 1937, with chief complaint of pain and stiffness of left shoulder, low back pain and a sciatic syndrome. These symptoms were attributed to an injury sustained two weeks previously. Prior to this admission, the patient had been in the hospital in a critical condition for about three months, having been discharged September 26, 1937. Beginning with a carbuncle on his upper back, he had developed a severe hemolytic *Staphylococcic aureus* septicemia. During the course of this illness, the following complications were noted: five lung abscesses, hepatitis, empyema, atelectasis, metastatic skin abscesses and a renal carbuncle. It is interesting to note that the bones and joints escaped the infection at this time. Therapy consisted of surgical drainage of the carbuncle, transfusions, hemotherapy, antitoxin vaccine and bacteriophage. The patient improved generally under symptomatic treatment and measures to build up his general condition. On leaving the hospital, he was asymptomatic and continued to improve until the onset of the present illness. The injuries were treated as sprains, but did not respond to rest and physiotherapy.

Physical Examination on admission revealed an emaciated, debilitated, anemic young man. Temperature 102° F., pulse 100, respirations 24. The left shoulder was painful, the surface temperature was elevated, and tenderness was elicited upon pressure over the greater and lesser tuberosities. Slight fluctuation was demonstrable over the subacromial area. Rotation and elevation of the shoulder were restricted by muscle spasm. Examination of back revealed spasm of the erector spinae, pain on movement and percussion over lumbar vertebrae, and restricted straight leg-raising on left side. Heart, lungs and abdomen were negative. Leukocytosis 12,600, 79 per cent polymorphonuclears. Blood and casts were found in the urine. The temperature was of a septic type. Blood cultures were negative. Roentgenologic examination of left shoulder showed thickening of cortex along mesial aspect of left humerus; the spine showed a narrowed fifth lumbar intervertebral space, and prolapse of nucleus pulposi into the fourth and fifth lumbar vertebrae. Diagnostic bursal tap yielded seropurulent material which on culture showed

hemolytic *Staphylococcus aureus*. On December 2, 1937, drainage of the subacromial bursa was instituted and bloody pus evacuated. Finger exploration revealed a few fibrous strands beneath the acromion and tabs on the floor of the bursa. Perforation through the floor was neither observed nor felt. Systemic and local symptoms promptly subsided following operation. A plaster of paris jacket was applied to immobilize the spine, and the patient was discharged December 5, 1937 in care of his physician.

Case 3.—U. K., male, age 65, was admitted to the Mt. Sinai Hospital Clinic December 21, 1937, with a painful, swollen, stiff right shoulder, of sudden onset, unknown etiology, and of five days' duration.

Physical Examination revealed a well developed Russian, with advanced peripheral arteriosclerosis, dental caries and diseased tonsils. Owing to language difficulties, a

FIG. 1.—Case 4: Showing the external contour of the effusion in the left subacromial bursa.

clear idea of his previous medical history could not be obtained. Temperature 100° F.; pulse 90. The right shoulder presented an enormous effusion in the region of the subacromial bursa, as evidenced by the marked roundness of the shoulder and fluctuation beneath the acromion process. Aspiration yielded thick, creamy, greenish pus, which on culture and smear examination was negative for T.B., or other organisms. Under novocain anesthesia, a two inch, linear incision was made below the acromion process. Upon separating the fibers of the deltoid, the tense bursal wall was noted. Incision yielded a copious flow of flaky, greenish pus. Finger exploration revealed a roughened floor, but capsular tears, villi, or tabs were not present. The peripheral termination of the bursa was located about three inches below the upper end of the humerus. Rubber dam was inserted for drainage. The patient did not return for further treatment.

Case 4.—J. B., male, age 52, was admitted to the Mt. Sinai Hospital October 30, 1937, complaining of pain and swelling of the left wrist and left knee, cough, and loss of weight. Three months prior to admission, the patient had developed a cough, following an acute upper respiratory infection. The cough was productive and associated with chest pain. On one occasion, blood specks were noted. Ten days before admission, he developed pain and swelling of left knee and left wrist.

Physical Examination revealed an emaciated, middle-aged white male, with herpes labialis, coated tongue, and congested pharynx. Chest revealed bubbling râles at left base. Heart showed slight enlargement, irregular cardiac rhythm and poor tone. Left knee was swollen, painful, and flexed. Left wrist and hand were swollen, movements restricted and painful. Temperature was moderately elevated, and irregular, fluctuating between 99° and 101° F. Blood culture showed the presence of hemolytic *Streptococci*. Roentgenologic examination of the chest revealed enlarged heart, right hilar mass and normal knee and wrist joints. Under sulphanilamide therapy, 15 grains four times daily, the joint symptoms subsided and the blood culture became negative. The patient subsequently developed a very large pericardial effusion, which was repeatedly tapped during the following six weeks. The total amount withdrawn was approximately 6,500 cc. On December 15, 1937, a painless effusion was noted in the subacromial bursa of the left shoulder (Fig. 1). Abduction and rotation of this joint were restricted by contracture of scapulohumeral muscles. Aspiration of the subacromial bursa yielded bloody pus. Under local anesthesia, a two inch, linear incision was made over the shoulder, the fibers of the deltoid muscle separated, and a tense distended subdeltoid sac was revealed. Incision resulted in evacuation of a considerable amount of pus. Finger exploration revealed a smooth bursal floor with no apparent perforation through the capsule; the wall itself was thick and congested. Culture of the pus removed revealed a hemolytic Streptococcus—the same organism which had been responsible for the septicemia earlier in the course of the disease. Roentgenologic examination of the left shoulder showed evidences of erosion and absorption of the greater tuberosity of the head of the humerus. This patient is still in the hospital with the cardiac condition. He has at the present time an adhesive pericarditis which interferes markedly with the circulation. An operation has been considered to relieve this condition. Range of motion of the shoulder is still greatly limited.

Hematogenous, Suppurative Prepatellar Bursitis

Case 5.—S. C., male, age 70, was admitted to the Northern Liberties Hospital September 28, 1935, complaining of pain in the right ear of ten days' duration, pain in the right knee, fever, and prostration. Temperature 105° F., pulse 130, respirations 30. Two days before admission, a paracentesis of the right ear was performed, resulting in a discharge of pus.

Physical Examination revealed an obese male; B.P. 160/80, cardiac decompensation, moist râles in both lungs, enlarged liver and a swollen, painful right knee. Roentgenologic examination of the right ear revealed a cloudy mastoid with thinning and absorption of the cells and a thickening of the anterior wall of the lateral sinus; the right knee was negative. W.B.C. 15,800, polymorphonuclears 95 per cent, R.B.C. 4,150,000, Hb. 77 per cent. Blood sugar 133, blood culture sterile, Wassermann negative. A swollen prepatellar bursa was recognized October 3, 1935, which yielded thick creamy pus on aspiration. The bursa was incised and drained. Following this procedure, the temperature which had been of the septic type gradually dropped to a lower level. This patient remained in the hospital for about one month. His ear symptoms gradually lessened. No radical procedures upon the mastoid were attempted, owing to his desperate condition. Smear studies from ear discharge and knee revealed a hemolytic Streptococcus.

Hematogenous Suppurative Gluteal Bursitis

Case 6.—M. A., female, age 27, married, was admitted to Mt. Sinai Hospital October 18, 1936, complaining of chills, fever, prostration, and severe pain in the left buttock of eight days' duration, sudden in onset, and attributed to exposure to cold and wet. Except for bronchiectasis, her previous medical history was irrelevant. She had had three children, the last having been born two and one-half months ago.

Physical Examination revealed a well-developed woman, acutely ill; temperature of

103° F., pulse 130, respirations 28; and an acute inflammatory process involving either the left ilium or hip joint, and chronic pulmonary pathology (bronchiectasis). Objective findings were marked tenderness over a limited area in the left buttock about four fingerbreadths below the crest of the left ilium, and one fingerbreadth lateral to the outer border of the sacrum. Flexion of either extended leg upon the abdomen accentuated the pain in the right buttock. The upper extremity of the thigh, in the trochanteric region, was not tender to pressure. There was no demonstrable swelling in this region.

Vaginal examination revealed no abnormality other than a cervical discharge. Rectal examination was negative. Roentgenologic examination following a barium enema revealed a normal colon; the pelvis and left hip joint were negative except for a small area of increased density, suggestive of a calcium deposit in the soft structures of the left buttock. R.B.C. 3,450,000, W.B.C. 15,500, polymorphonuclears 84 per cent, small lymphocytes 13 per cent, Pr. 3, Hb. 74, urea nitrogen 15.8, blood sugar 99, Wassermann, Widal and compliment fixation for gonococci negative. Uranalysis: Faint trace of albumen, few W.B.C. and R.B.C., no casts. Blood culture was sterile. Although the roentgenograms were negative for bone pathology a provisional diagnosis of acute osteomyelitis of left ilium was made, and the patient was treated expectantly for three weeks. During this period, the pain in left buttock persisted, temperature fluctuated between 99° and 101° F., and the pulse rate was accelerated, ranging between 100 and 120. She received several blood transfusions, supportive measures and sedatives. On one occasion aspiration of the right buttock resulted in a dry tap. A plaster of paris encasement was applied October 26, 1937, but was removed a week later since it did not relieve the local symptoms.

Operation.—November 4, 1937: The left ilium was explored through a large incision over the left buttock, exposing the sacro-iliac joint and ilium. Careful palpation and inspection failed to reveal any periosteal thickening or subperiosteal abscess. A tube drain was inserted into the lower angle of the wound. Following this procedure, the temperature became more elevated and assumed a septic type. Blood cultures continued to be sterile, and roentgenologic examination failed to reveal any bone involvement. The above symptoms persisted until November 26, 1937, at which time there occurred a spontaneous rupture of pus through the healed incision in the buttock. From then on she continued to convalesce satisfactorily and was discharged December 13, 1937, with a small draining sinus in the buttock. It is highly probable that the bronchiectasis was the primary source of infection, and that the gluteal abscess was a secondary metastatic manifestation of this condition. Antecedent trauma or other illnesses were not in evidence. Smear studies of the pus were not made.

COMMENT.—Inflammation of the bursae beneath the gluteal muscles constitutes one of the most puzzling and frequently overlooked lesions in the vicinity of the hip joint. The acute syndrome simulates hip joint disease, osteomyelitis of the ilium, or acute septic arthritis of the sacro-iliac joint. The onset is acute, with high temperature, pain in the hip or buttock, and prostration. Pressure about the hip elicits exquisite tenderness, pain is accentuated by movements of the joint. Occasionally a sciatic syndrome is present due to pressure on the sciatic or gluteal nerves. Diagnosis of acute suppurative arthritis of the hip joint is usually made in these patients, and an arthrotomy performed. Thus an otherwise simple lesion is converted into a very serious condition, which threatens life or causes a permanent crippling disability.

In studying the anatomy of the buttock, we have been impressed with the large number of bursae which are located in this region. Spalteholtz estimates the number to be from 10 to 30. According to Quain, among the more

important, constant bursae in this region is the large multilocular trochanteric bursa, and a number of smaller bursae connected with the gluteus medius and minimus, piriformis and ischium. J. E. Milgram[8] has given us an excellent description of the connection between these bursae and the fascial planes of the thigh.

When the trochanteric bursa is affected there is tenderness over the great trochanter, and pain on movement of the limb. The extremity is flexed, abducted, and externally rotated. A resilient tumor develops posterior to the trochanter, underneath the aponeurosis of the gluteus maximus, which obliterates the hollow behind the trochanter. The gluteal fold may be effaced. In advanced cases, the purulent collection may spread along the fascial planes of the thigh, down to the external condyle. The finger-like prolongation of this bursa, which extends towards the sciatic nerve, may be involved, in which event severe pain down the leg may result.

Bursitis about the buttock, other than the trochanteric, is differentiated by the anatomic situation of the bursae, and by eliciting pain upon voluntary contraction of the muscle overlying the involved bursa. Four bursae, two under the gluteus medius, one under the gluteus minimus, and one at the edge of the piriformis, are closely associated, and particularly related to the summit of the trochanter. Symptoms point above the trochanter and are confined to the side of the pelvis; they may simulate osteomyelitis of the ilium. In these cases, the inflammation may give rise to deep-seated pain in the buttock, radiating down the leg, without any striking change in the contour of the buttock (Case 6).

In acute suppurations of the hip joint or osteomyelitis involving the upper end of the femur, all movements are restricted by painful muscular spasm. Jarring of the joint is painful. There is no swelling or tenderness of the buttock, but there is a fulness of the upper thigh. The capsule of the hip is distended and fluctuation may be demonstrable over its anterior aspect. Diagnostic tap is conclusive. Osteomyelitis of the ilium and suppurative arthritis of the sacro-iliac joint begin with a more violent onset, both locally and constitutionally. While roentgenologic examinations are valueless early in the course of these conditions, positive evidence becomes available as the disease progresses.

CONCLUSIONS

(1) Purulent collections in bursal cavities may occur as complications in the course of blood stream infections, and give rise to local symptoms which simulate septic arthritis or osteomyelitis. Case histories of six patients presenting these lesions are herewith recorded.

(2) A knowledge of the location, extent, and possible pathology of bursae is essential in differentiating these conditions from intra-articular or osseus lesions. The roentgenologic examination and diagnostic tap are the most reliable diagnostic procedures.

(3) Suppurative gluteal bursitis should always be considered as a diagnostic possibility in cases of deepseated pain in the buttock, associated with constitutional symptoms, and negative roentgenologic findings.

(4) Incision and drainage are indicated when fluctuation is demonstrable.

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CHROMICIZED BEEF TENDON FOR INTERNAL FIXATION OF FRACTURES *

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THE writer is familiar with the various methods of internal fixation of fractures, such as autogenous, osteoperiosteal, massive onlay, inlay and beef bone grafts and also the employment of pins or pegs, *etc.*, in and outside of the medullary canal; as well as pins, nails and plates used for the internal fixation of fractures, all of which have been used for internal fixation when it was considered they were indicated, and with which more or less good results have been obtained. However, the observations of Venable, Stuck and Beach[1] on the various types of metal used for internal fixation of bone and the accompanying electrolysis have caused me to question, somewhat, the employment of metal for fixation. Likewise, there have been many discussions both for and against all the methods and materials used in internal bone fixation. The whole question is, apparently, far from settled and, therefore, the new material herewith suggested may not be out of place.

Desiderata.—Some four years ago, it occurred to the writer that it would be desirable to have a material that, as nearly as possible, possessed the qualities of an autogenous graft without the necessity of removing the graft from another part of the body and subjecting the patient to this additional surgery. It was realized that no material could be obtained that would reproduce bone. This material, therefore, could only act as a splint; should be properly sterilized and placed in glass tubes; should be absorbable, but should stay in place a sufficient length of time, and maintain reduction of the fracture long enough for union to get well started or be completed. The material should also be well tolerated by the tissues. It should be easy to work with, and come fashioned as a plate, cuff, pin or peg; as these forms of material are most acceptable to the majority of bone surgeons. It should be easily secured and of moderate cost.

Such a material could, apparently, only be procured from animals. The tendo achillis of the steer was considered to offer a structure of sufficient strength and proper histologic requirements. From the results obtained by Shipley with ox fascia, we were reasonably certain that this tendon obtained from the steer would be well tolerated by the tissues, if properly prepared.

Chromicized beef tendon was, therefore, prepared in plates, cuffs and pegs by a reliable manufacturer† of catgut products, sterilized and put up in glass tubes (Fig. 1). After working with this preparation, we found that it was

* Read before the Southern Surgical Association, at Birmingham, Ala., December 7, 1937.

† Davis and Geck, Inc., Brooklyn, N. Y.

absolutely sterile; easy to work with; did not show on a roentgenogram; would remain in position 60 to 90 days; had sufficient strength; and did maintain reduction of the fracture if properly introduced. It was well tolerated by the tissues and did not interfere with bone growth. We feel that 60 to 90 days is sufficient time for bony union to take place if it is going to occur, and that some type of splint, either of plaster or metal, should be used in conjunction with this material. We do not advise the use of chromicized beef tendon unless an open operation is indicated and when other, more simple methods have failed.

In using chromicized beef tendon we have followed the methods as out-

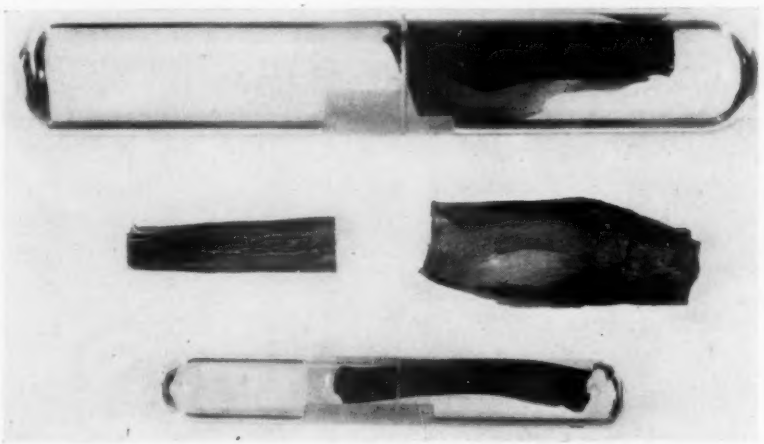

FIG. 1.—The appearance of both a peg and a cuff of the chromicized beef tendon as it comes in tubes.

lined. The fracture having been exposed through a suitable incision, it is studied visually and the most desirable method of fixation is decided upon, as roentgenograms do not always give one an accurate idea of the fracture. The tendon is thoroughly washed in sterile water to remove all chemicals. If a cuff is to be used, it is placed over the periosteum and line of fracture, the ends of the latter having been first brought into proper alignment and held in position with any form of mechanical apparatus available. At either end of the cuff, holes are bored through it and the bone large enough to take a heavy kangaroo tendon suture. This suture is tied around the bone and over the cuff several times, thereby holding it firmly in position. The cuff should not extend over two-thirds of the circumference of the bone upon which it is being applied (Fig. 2). The blood supply should not be entirely excluded from the line of fracture. The cuff may also be formed into a roll for use in the medullary canal; the roll should not be a tight one so that it may permit the free circulation of fluids through it. This method overcomes most of the usual objections to materials placed in the medullary canal. Here also, holes are bored through either end of the cuff and bone, and the cuff is an-

chored firmly in place with heavy kangaroo tendon firmly tied around the bone several times (Figs. 3 and 4). On the large bones it may be necessary to use several cuffs or plates to secure firm fixation. This is a matter of personal opinion and experience.

The chromicized beef tendon pins or pegs are used in the same manner as bone or metal pins or pegs in oblique fractures (Fig. 5), fractures of the

FIG. 2. FIG. 3.

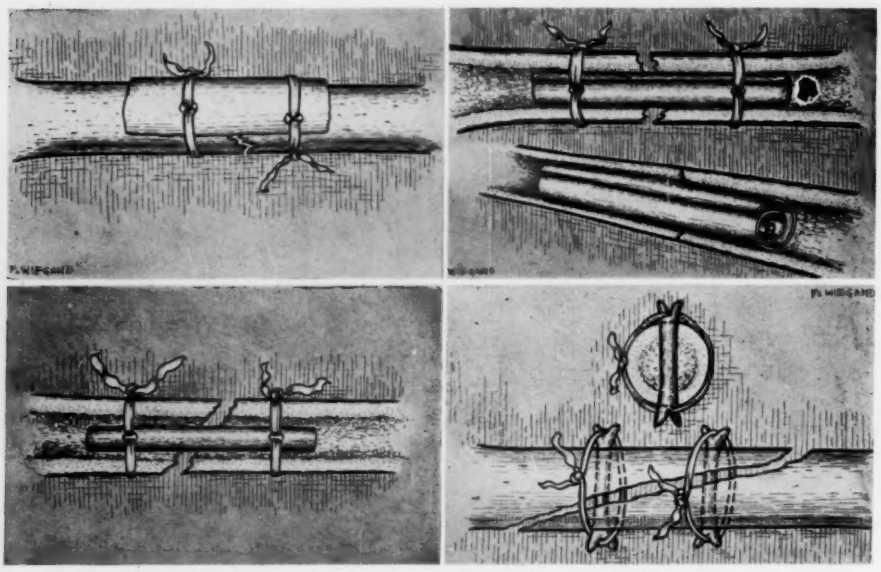

FIG. 4. FIG. 5.

FIG. 2.—The appearance of the plate or cuff applied to the fracture and anchored in place by kangaroo tendon passed through holes bored through both the cuff and the bone.

FIG. 3.—The appearance of the cuff rolled into a roll and placed in the medullary canal, and also anchored in position by kangaroo tendon passed through both the cuff and the bone.

FIG. 4.—The chromicized beef tendon peg used in the medullary canal; illustrating, particularly, the loose fit of the peg.

FIG. 5.—Illustrating the manner in which the pegs are passed through an oblique fracture with the ends split and anchored in position with kangaroo tendon.

condyles or tuberosities (Fig. 6), and fractures of the olecranon process (Fig. 7), *etc.* These pins or pegs may also be used in the medullary canal if desired. It has been found that when these pegs are anchored in the medullary canal with heavy kangaroo tendon passed through holes bored through both ends of the tendon peg and the bone, it is not necessary for the tendon peg to fit the medullary canal tightly. The tendon peg also has a certain amount of give or spring to it which permits it to be put in place more easily and without breaking. These properties cause less damage to the endosteum, and also permit a free circulation of blood and serum around the peg. When chromicized beef tendon pegs are used in oblique fractures, it is felt that it is a good idea to let the pegs extend beyond the bone on either side a short distance. These ends can then be split with bone forceps and kangaroo tendon tied around the bone and through the split ends of the pegs, which will hold them in position and keep them from slipping in either direction (inset Fig. 5).

Chromicized beef tendon can easily be cut with heavy scissors or bone cutting forceps. This permits the shaping of the peg or cuff without the use of motor saws, bone rasps, *etc.*, thereby shortening the time of the operation considerably.

It is not claimed that chromicized beef tendon should be used in all fractures, but it is felt that it has a useful place in the armamentarium for bone surgery and in many instances can be employed to great advantage. We feel that it possesses many desirable qualities and is well worth consideration.

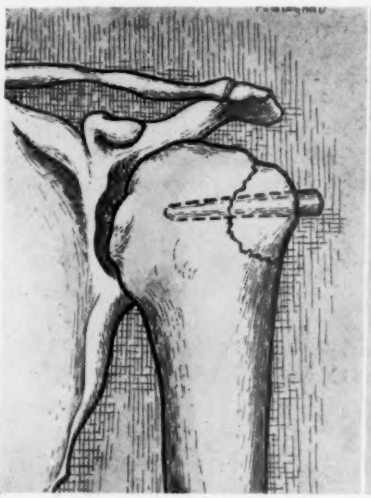

FIG. 6.—Showing the employment of the chromicized beef tendon peg for fixing fractures of the tuberosities.

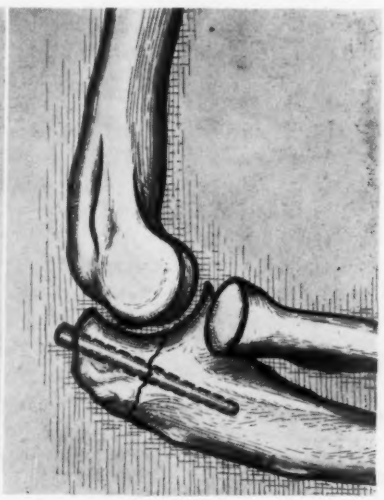

FIG. 7.—Showing the method of fixing a fracture of the olecranon with a chromicized beef tendon peg.

ILLUSTRATIVE CASE REPORTS

Case 1.—Female, age 35. Automobile accident. Complete separation of greater tuberosity of humerus, right arm, with anterior dislocation. Nailed beef tendon peg, Thomas splint, arm in abduction. *Result:* Complete union in five weeks' time.

Case 2.—Female, age 26. Automobile accident. Fracture of right olecranon. Complete separation and dislocation. Olecranon drilled and nailed, using beef tendon peg. *Result:* Union; active and passive motion in five weeks' time.

Case 3.—Male, age 32. Fracture of both bones of right forearm, middle third; caused by slate fall, and was unable to maintain alignment. Beef tendon cuff-type operation. Cuffs tied in place with chromic catgut. *Result:* Union in six weeks' time. Bisected plaster encasement fixation.

Case 4.—Male, age 40. Oblique fracture of left humerus, middle third; caused by slate fall; muscle between fracture line. Two beef tendon pegs were driven transversely and tied in position by kangaroo tendon. *Result:* Union in seven weeks' time. Thomas arm splint applied.

Case 5.—Male, age 28. Fractured first phalanx, right index finger. Labor accident. Intramedullary beef tendon peg used and finger splint fixation. *Result:* Union in five weeks' time.

Case 6.—Male, age 30. Automobile accident. Fracture of left femur, middle third. Muscle between line of fracture. Application of two beef tendon cuffs. Applied Thomas leg splint, and walking caliper. *Result:* Union in ten weeks' time.

Case 7.—Male, age 15. Fracture of both bones, left forearm, middle third. Unable to maintain proper reduction. Beef tendon cuff applied to both radius and ulna, anchored in place by kangaroo tendon. *Result:* Union in seven weeks' time. Anterior and posterior molded plaster of paris splint applied.

Case 8.—Male, age 45. Fracture of lower third left tibia. Intramedullary rolled cuff anchored with kangaroo tendon. Also osteoperiosteal bone graft used in same case, with bone chips. *Result:* Union in 12 weeks' time. Plaster encasement fixation.

Case 9.—Female, age 66. Fracture of left humerus. Automobile accident. Seen after several attempts at reduction. Fracture at juncture of lower and middle thirds. Beef tendon cuff anchored with kangaroo tendon. *Result:* Union in eight weeks' time. Thomas arm splint fixation.

Case 10.—Male, age 56. Rather heavy, obese type. Fracture of middle third right femur. Fracture reduced, Thomas splint and later plaster encasement. Fracture was treated in this manner for over one year, with a resulting nonunion and no callus formation whatever.

At the end of one year, an open reduction was undertaken by Drs. J. Duffy Hancock and Ben Wilson Smock, Louisville, Ky. The ends of the bone were cleaned of all fibrous material and exudate, approximated and retained by an intramedullary beef tendon splint. Roentgenologic examinations made at regular intervals showed the bones to be in excellent apposition, with no callus formation. The leg was reopened at the end of four months and the fracture reduced and splinted with a beef bone intramedullary graft. There was no trace of the beef tendon found at the time the leg was opened up four months after its application, to the femur.

Result.—Six months after the beef bone graft had been employed, the patient was found to still have a false joint, with nonunion. He is now able to get about with the use of a cane.

COMMENT.—The beef tendon splint served its purpose in splinting and supporting the line of fracture perfectly; and was demonstrated to have been absorbed at the end of four months. We feel that it worked perfectly as a splint for open bone reduction; that it was in no way to blame for the nonunion, as previous treatment and subsequent treatment using different methods were also failures in effecting the uniting of this fracture.

Appreciation is made to Dr. Ralph O. Clock, of the Davis and Geck Company of New York, for his assistance in the preparation of this material and for donating a supply sufficient to enable us to reach a conclusion regarding its availability.

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BRIEF COMMUNICATIONS AND CASE REPORTS

MALIGNANT TRANSFORMATION OF A SOLITARY SIGMOID ADENOMA

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IT IS generally believed that there is a marked tendency for adenomata of the large bowel to undergo malignant transformation. The evidence, which is wholly indirect and circumstantial, has been questioned upon the grounds that their association may be coincidental. The case herewith reported we believe affords direct clinical evidence of such transformation, and is substantiated by pathologic sections.

Case Report.—(Hospital No. 404403): J. G., male, age 45, Russian, tailor, was first seen in the Mt. Sinai Hospital Out-Patient Department in June, 1936. He had been well until ten years prior when he began to have painful, bloody bowel movements. He was told he had fissures and hemorrhoids and he was operated upon at another institution. No relief was obtained, however, for he continued to have attacks of painful, bloody diarrhea. This continued in a milder form through the ensuing years and no diagnostic therapeutic procedures were undertaken until two years prior to his admission when he began to suffer from episodes of severe constipation alternating with attacks of diarrhea, and the passage of "pus, mucus and blood." Often he would have as many as 12 movements in 24 hours. His physician, after making a roentgenologic and proctoscopic examination, told him that he had hemorrhoids, anal fissures and "catarrh of the bowel." He was admitted to another institution in January, 1936, and again an hemorrhoidectomy was performed. Several weeks later rectal bleeding recurred, and he also developed epistaxis and generalized petechiae. He was readmitted to the same hospital where blood studies revealed R.B.C. 3,500,000, platelets 90,000, bleeding time 30 minutes, clotting time 11 minutes. He received two transfusions and had snake venom injections administered. The attacks of epistaxis and petechiae stopped, and at the time of his discharge from the hospital the platelet count had risen to 200,000. Mild, occasional rectal bleeding continued. Five months later, however, there was a recurrence of all his previous symptoms—epistaxis, petechial spots and severe rectal bleeding. He was then referred to the Mt. Sinai Hospital. It was ascertained at this time that during the past two years he had been on a diet of bread, meat and potatoes almost exclusively.

Physical Examination disclosed a chronically ill, pale, poorly nourished, middle aged male. There were numerous petechiae present over the general body surface. The liver and spleen could not be felt. There were no palpable lymph nodes. Chest negative. Urine negative. Blood Wassermann negative. Blood examination showed: Hemoglobin 76 per cent, R.B.C. 5,220,000, W.B.C. 10,950. Differential, segmented polys 70 per cent, nonsegmented 3 per cent, lymphocytes 22 per cent, monocytes 3 per cent, eosinophiles 2 per cent. Platelets 130,000. Bleeding time 6½ minutes, coagulation time 7½ minutes.

Treatment with snake venom was continued for a time. The epistaxis and petechiae

Submitted for publication February 21, 1938.

diminished but the episodes of bloody diarrhea continued and he was referred to the Rectal Clinic.

Proctologic Examination.—Inspection: The peri-anal skin was normal except for a few small skin tabs. Digital: No abnormalities were noted. Anoscopy: The anal canal showed definite evidence of scarring with obliteration of all normal landmarks. Sigmoidoscopy: At full length a polyp the size of a large cherry was encountered. The tumor appeared normally pink in color and had the usual velvety surface seen in benign polypi. When the end of the sigmoidoscope was passed over the tumor, one obtained the impression that the tumor was soft.

Clinically the lesion was definitely benign, but as a routine measure biopsy was

FIG. 1.—Photomicrograph of a typical section of the multiple biopsies showing the histologic characteristics of an adenomatous polyp.

performed, three large pieces being taken from different areas. The mucosa was otherwise normal. A barium enema was reported as revealing no evidence of an organic lesion.

Pathologic Report.—By Dr. Paul Klemperer (No. 58023): "Fragments of tissue from colon. They consist of elongated, often branching glands within an hyperemic stroma infiltrated by plasma cells and polymorphonuclear leukocytes. There are glands lined by goblet cells, but the greater number of glands are lined by high columnar epithelium with dark rod-shaped nuclei, often multilayered. Mitotic figures are seen occasionally. *Pathologic Diagnosis:* Fragments of adenomatous polyp" (Fig. 1).

After the negative pathologic report and the negative barium enema, it was decided to coagulate the polyp. Sigmoidoscopy was again performed and the polyp

brought into view. When the coagulating electrode was introduced the tumor slipped back beyond the reach of the sigmoidoscope. After this had occurred several times, it was inferred that the polyp was on a long pedicle. The tumor was ultimately visualized and a complete surface coagulation done. All bleeding ceased after the coagulation. Attempts at further coagulation were made at frequent intervals, but because of poor preparation the tumor could not be visualized and it was not until several weeks later that a successful sigmoidoscopy could be accomplished. At this examination, eight weeks after the first observation and biopsy, the tumor presented an entirely different appearance. It now appeared dark red in color, definitely lobulated and felt distinctly hard through the medium of the sigmoidoscope. In spite of the recent negative biopsy, the

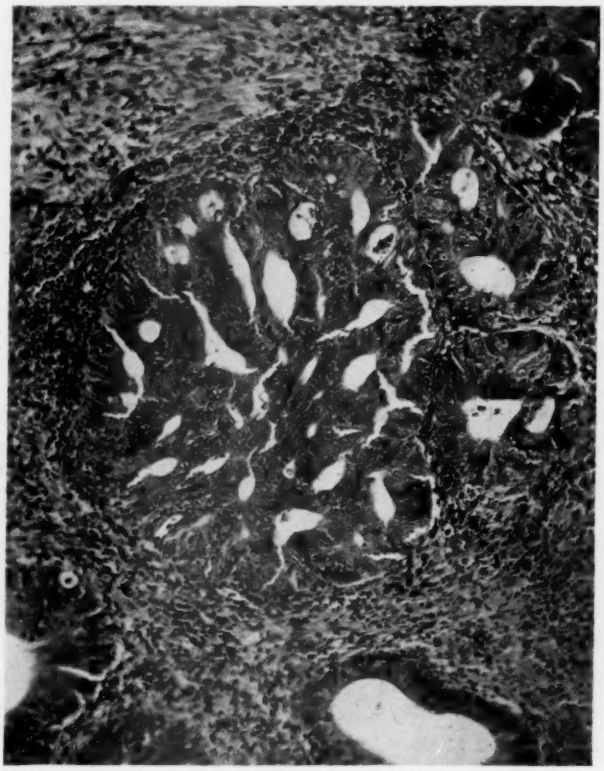

FIG. 2.—Photomicrograph of a section of the subsequent biopsy, eight weeks, showing adenocarcinoma.

tumor appeared so decidedly malignant, that another biopsy was immediately performed. Without awaiting the report of the pathologist, complete surface coagulation was done.

Pathologic Report.—By Dr. Paul Klemperer (No. 58448): "The outstanding feature in the histology is the appearance of the glands. They are strikingly elongated and branching and very many are lined by low columnar cells in disorderly arrangement with large vesicular nuclei and one or two large eosinophile nucleoli. Mitotic figures are very frequent. There are other glands which are lined by high columnar cells with rod-shaped nuclei, the type cell seen in the previous biopsy. *Pathologic Diagnosis:* Adenocarcinoma" (Fig. 2).

The patient was admitted to the surgical service, February 8, 1937, and was operated upon by Dr. A. J. Beller.

Operation.—February 24, 1937: Under spinal anesthesia, the abdomen was opened through a left rectus incision. The entire colon was palpated and found to be normal except for the sigmoid where a movable mass could be felt. The liver was apparently normal and there was no involvement of mesenteric nodes. The sigmoid was opened by a vertical incision exposing a cherry-sized, irregularly nodular, somewhat firm tumor on a pedicle about one and one-half inches long. The pedicle was ligated at its base, cut with the cautery and the tumor and pedicle removed. The sigmoid was then closed transversely. The abdomen was closed in layers. The patient made an uneventful recovery and was discharged on the thirteenth day postoperatively.

Pathologic Report.—By Dr. Paul Klemperer (No. 58629): "Adenomatous polyp with early adenocarcinoma. There is no involvement of the pedicle."

The patient has been seen frequently in the Follow-Up and Rectal Clinics and was last examined January 12, 1938. He has been on a normal diet and has gained 25 pounds. There have been no evidences of petechiae or epistaxis and there have been no further episodes of diarrhea or rectal bleeding. Sigmoidoscopy as well as barium enema have been entirely negative. Blood examination: Hb. 98 per cent, R.B.C. 5,010,000, W.B.C. 7,500. Differential: Polys. 70 per cent, lymph. 23 per cent, monocytes 5 per cent, eosinophiles 1 per cent, basophiles 1 per cent. Platelets 240,000, Bleeding time 1 minute, coagulation time 16 minutes. The clot retracted normally. The tourniquet test was negative.

COMMENT.—We do not know with certainty how long the adenoma had been present, but feel reasonably sure that it had existed for ten years. The reasons for this are: First, the ten year history of rectal bleeding, unrelieved by two hemorrhoidectomies performed eight years apart; second, the blood dyscrasia occurred but one year prior to his admission to the Rectal Clinic and presumably did not initiate the rectal hemorrhages but rather increased the tendency to them; and third, upon removal of the tumor all bleeding ceased. The temporary complicating blood dyscrasia was at first considered to be due to avitaminosis. Consultation with the hematologist, however, established the fact that this was merely a transitory idiopathic purpura.

When we first saw this tumor the clinical appearance, through the sigmoidoscope as well as the feel imparted through the instrument, was typical of a benign adenoma. This was verified by biopsy. Realizing full well the pathologic variations that may exist in different parts of the same tumor, three large pieces were removed and each was sectioned. Eight weeks later the clinical appearance had changed to such an extent that we immediately made a clinical diagnosis of malignancy and took new sections. Our clinical diagnosis was again confirmed by the pathologist. There is but little doubt that during this short interval the transition from benign to malignant occurred. As additional evidence of the very early stage of the malignancy we have the fact that the pedicle, which was sectioned in several places, failed to show any neoplastic cells.

It is possible that the coagulation may have been the exciting trauma which resulted in the profound change. This of course is open to question, but in no way detracts from the fact that a malignant transformation did occur in a proven benign solitary adenoma.

INTUSSUSCEPTION OF THE APPENDIX

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UP TO 1922, Szenes[1] was able to collect 58 cases of intussusception of the appendix from the literature. In 1927, Huddy[2] added a case of his own, three which apparently had been overlooked by Szenes, and seven others. Both Szenes and Huddy seem to have overlooked the cases of Curry and Shaw,[3] and Farr.[4] Since 1927, the cases of Anzilotti,[5] Withrow,[6] Hamilton,[7] MacDermott,[8] Mitchell,[9] Esaw,[10] Coopernail,[11] and Bosi[12] have been published. To these should probably be added the cases of Spurney and Nyquist,[13] and Hipsley.[14] In all, some 80 cases of intussusception of the appendix have been reported.

As pointed out by Huddy, and confirmed by subsequent reports, "by far the greater number of cases arise in young children." The invagination of the appendix may be chronic or subacute and vomiting and loss of weight have been noted. A sequel to intussusception of the appendix occurs when the inverted mass is carried forward by peristaltic action and drags the ileocecal valve along the colon producing a major intussusception. Moschowitz[15] observed that cases of intussusception of the appendix had a "more or less protracted history of repeated attacks of severe abdominal cramps occurring intermittently with periods of well being." Palpable tumor and blood in the stool have been noted. Where the appendix may be disinvaginated, its simple removal should suffice to cure. In many cases, however, this cannot be accomplished and it has become necessary to resect the cecum.

Case Report.—P. S., age 9, was admitted to the Evanston Hospital March 15, 1938. Seven years previously (September 14, 1931) the patient was sent to the Evanston Hospital by Dr. C. A. Aldrich with a diagnosis of intussusception. At that time he had had cramp-like pains which came on at 20 minute intervals all during one night. The pain was relieved following an enema. Doctor Aldrich felt that there had been an intussusception which had reduced following the enema. For a number of years previous to the second admission to the hospital the patient had had attacks of abdominal pain which were never definite enough to call appendicitis. Three weeks before admission he had an attack of generalized abdominal pain with vomiting. After a few hours the pain localized in the right lower quadrant. He experienced pain in the abdomen as recently as the day before admission. Physical examination was negative save for rather marked tenderness and some rigidity in the right lower quadrant. The leukocyte count at this time was 7,000, although it had been 10,000 a few days previously. The urine was normal.

Operation.—March 16, 1938: The appendix was found to be at least one-half inch in diameter and very firm and edematous. There were some petechial hemorrhages on its surface. It was attached to the cecum at almost a right angle. At the junction of the appendix and the cecum a smooth confluence of serosa of cecum and appendix presented. This was due to old adhesions. The adhesions were dissected free and there was then disclosed a cleft running around the base of the appendix indicating an invagination of the appendix into the cecum. This finding was confirmed by feeling, through the opposite wall of the cecum, the protrusion for one-half to three-quarters of an inch of intussusception into the lumen of the cecum. By pressure on this protrusion into the cecum and slight traction on the appendix the intussusception was reduced. A con-

Submitted for publication April 7, 1938.

stricted ring on the appendix marked the furthest advance of the intussusception. The appendix was removed after catgut ligation and linen pursestring inversion. The McArthur-McBurney incision was closed without drainage and the boy made a rapid recovery (Fig. 1).

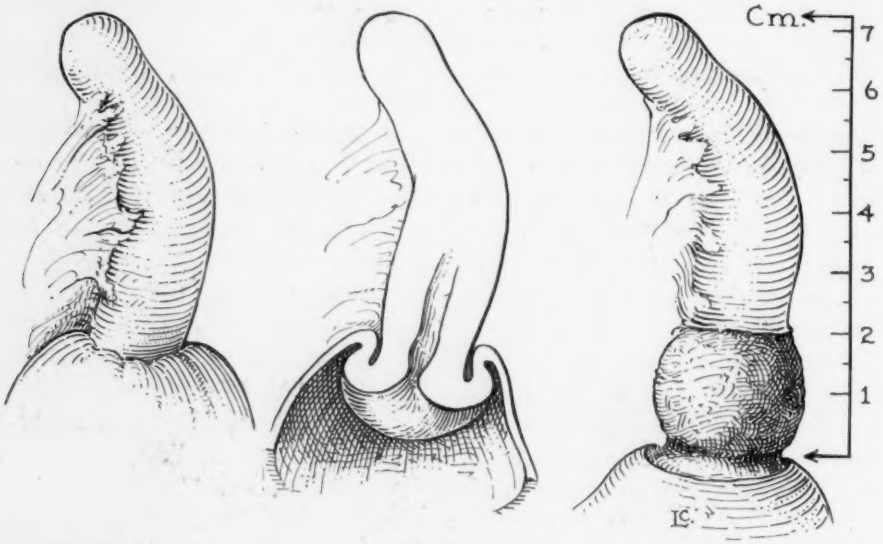

FIG. 1.—Intussusception of the appendix. (a) Condition found at operation. At the junction of the appendix and the cecum were old adhesions which are not shown in this drawing. (b) Schematic representation of the intussusception of the appendix into the cecum. The intussusceptum could be palpated through the wall of the cecum. (c) Appearance of the appendix after the intussusception was reduced.

SUMMARY

(1) Intussusception of the appendix is uncommon, some 80 cases being recorded in the literature.

(2) It occurs chiefly in young children; the diagnosis is difficult; the treatment may require resection of the cecum.

(3) A case of intussusception of the appendix is reported.

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A PRINCIPLE TO BE CONSIDERED IN TRANSPLANTING COSTAL CARTILAGE FOR REPAIRING DEFICIENCIES OF THE NASAL SKELETON

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IT IS the purpose of this paper to point out a method for more anatomically restoring loss or deficiencies in the bony and cartilaginous framework of the nose. The principle is of wide application and although suggested in part, prior to this communication by Gillies and McIndoe,[1] has not been clearly formulated in its entirety for those interested in reconstructive surgery of the face.

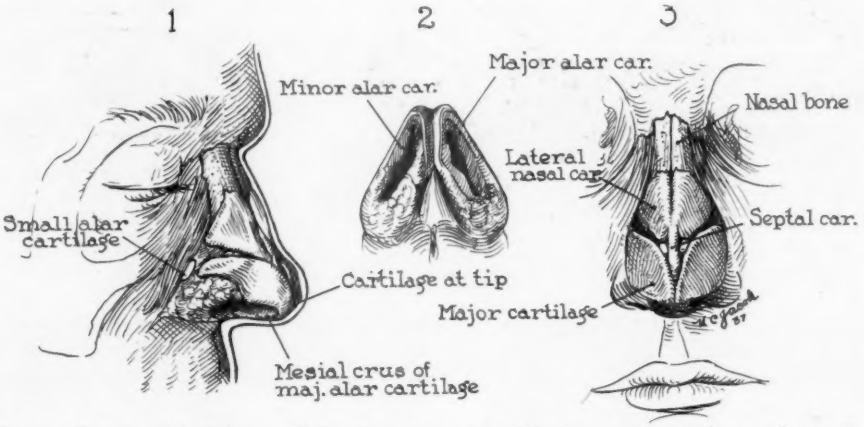

FIG. 1.—Normal nasal skeleton. Notice the manner in which the septal and alar cartilages are hinged. This allows mobility and yet retains form.

The nose consists of a skeleton of bone and cartilage, covered exteriorly by skin and fat and on the inside by mucous membrane. It is in effect a tent, the ridgepole of which is made up superiorly by the midline junction of the nasal bones, in midportion by the dorsal edge of the cartilage of the nasal septum, and at the tip by the folded, opposed edges of the major alar cartilages supported on the cartilage of the septum below. The pitched roof of the tent is supported on either side by the nasal bones above and the lateral and major alar cartilages below (Fig. 1).

This framework may be damaged, or partially or completely lost. The more common causes of such deficiencies in the supporting nasal skeleton are: Infection; trauma; and congenital failure of development. New growths usually destroy skin and mucous membrane as well.

Such a loss or disarrangement of bone and cartilage allows the skin covering to sag inward. This falling in of the nose changes its contour and in so doing changes the entire appearance of the face. It may, by decreasing the anteroposterior diameters of the nasal passages, seriously interfere with nasal

Submitted for publication January 6, 1938.

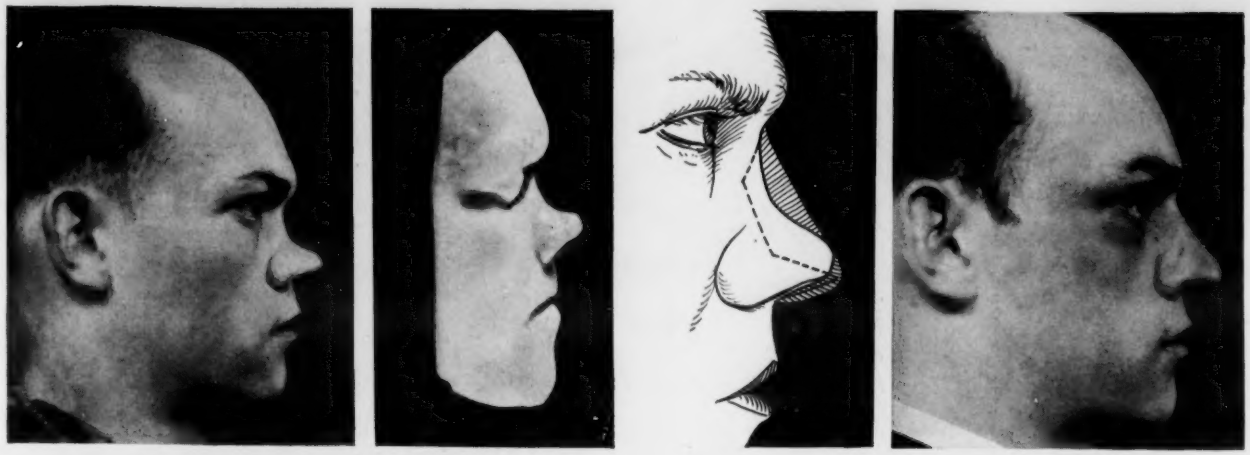

FIG. 2.—Falling in of dorsum of nose due to destruction of cartilage by pyogenic abscess. Nasal breathing impossible when recumbent. A hinged cartilage transplant corrected the appearance and provided a sufficient airway.

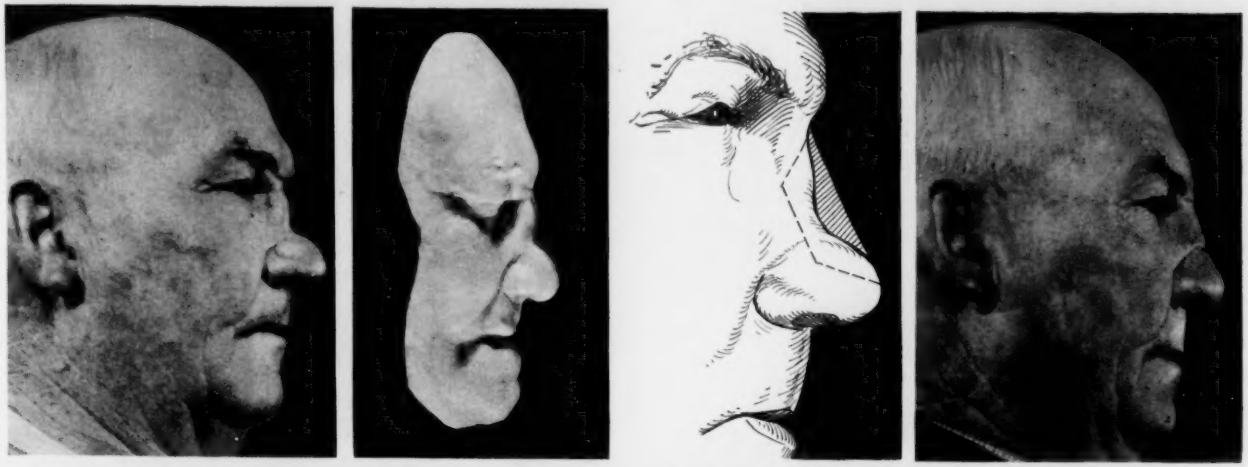

FIG. 3.—Partial loss and derangement of cartilaginous skeleton from compound fracture. Obstruction to breathing improved by submucous resection. Contour restored by hinged cartilage transplant.

FIG. 3.—Partial loss and derangement of cartilaginous skeleton from compound fracture. Obstruction to breathing improved by submucous resection. Contour restored by hinged cartilage transplant.

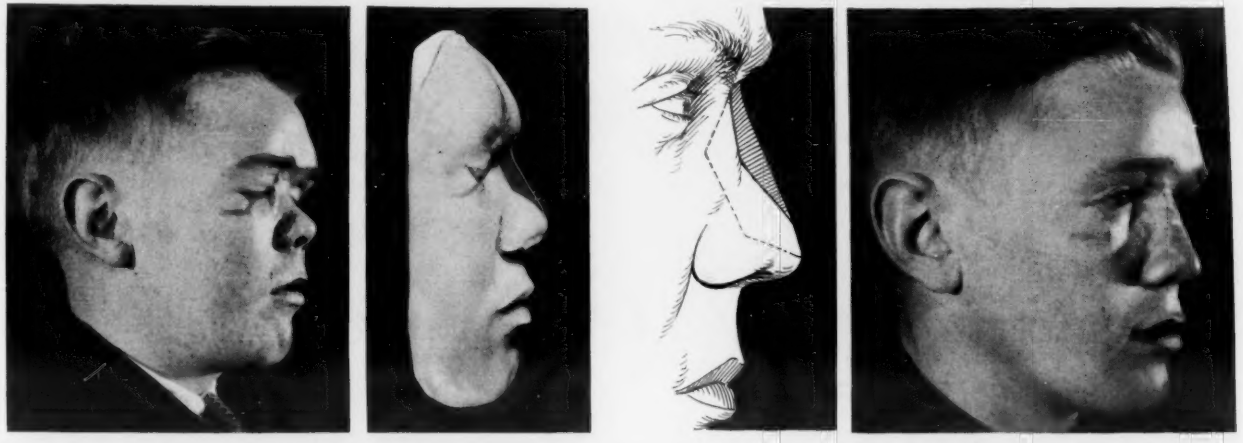

FIG. 4.—Derangement and loss of both cartilage and bone following compound telescoping fracture of frontal, nasal and maxillary bones. By a series of operations the open bite was corrected, the forehead depression built out, the soft tissues rearranged and the nose lengthened. The nose was then brought to its final appearance, on the right side by a cartilage transplant.

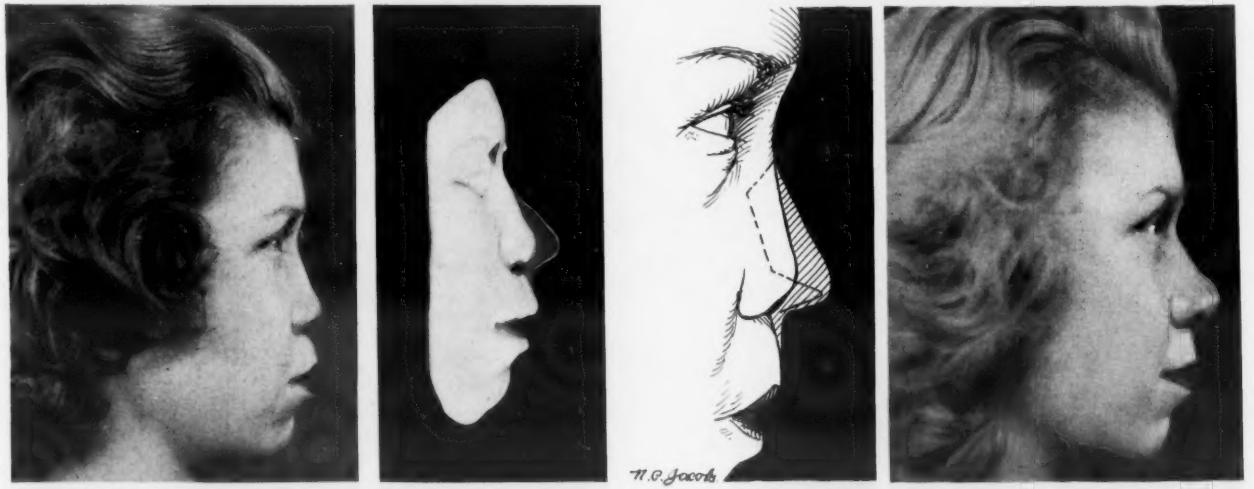

FIG. 5.—Marked retrocession of nose due to congenital absence of cartilaginous skeleton. Final appearance obtained in four stages: (1) Advancement of soft tissues; (2) lengthening soft tissues of columella; (3) an "L" shaped cartilage transplant to stretch the nasal skin still further forward; and (4) after some months a hinged transplant to construct the nasal tip.

respiration (Fig. 2). Thus loss of the nasal skeleton in part may damage both the appearance and function of the nose. Any method for correcting such a condition should attempt to improve both, and in effecting this the restoration should, without question, follow as nearly as possible the normal anatomic make-up.

For supplementing the nasal skeleton various substances have been employed. Among these are rubber, paraffin, ivory, celluloid, various metals,

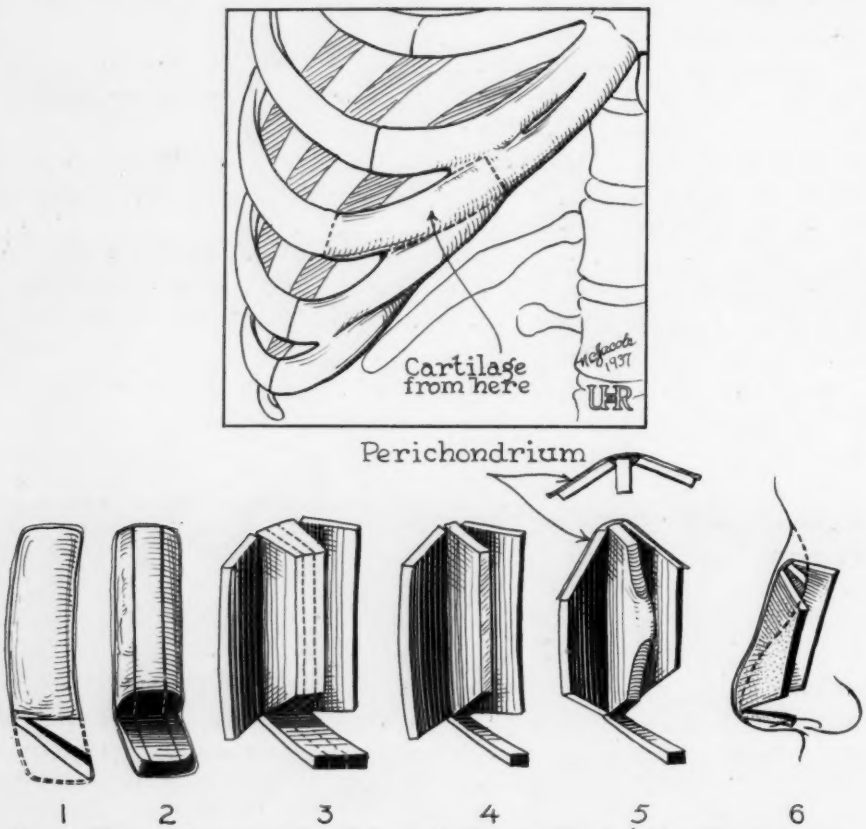

FIG. 6.—Diagrammatic representation of the construction of a hinged costal cartilage transplant.

cellulose plastics, heterogenous and autogenous bone and cartilage. I think it is safe to say that the human body tolerates foreign material poorly. Moreover, individuals are biologically so different that an inert substance which may persist in one, without an attempt of the body to cast it off, will not be well tolerated by another. In the present state of our knowledge concerning the exceedingly complex question of tissue transplantation, we feel that it is best to employ only autogenous material, and of these costal cartilage is better, on the whole, than bone. It can be more easily shaped to a desired form than bone and it exists on very little nourishment. Thus over a period of time bone may be absorbed but cartilage atrophies very little when transplanted subcutaneously and usually maintains its shape well.

In some instances a depression of the dorsum of the nose following trauma is not a result of actual cartilaginous loss but of disarrangement. In these cases there is usually a fracture of the cartilaginous skeleton with displacement downward in such a way as to partially obstruct the nasal airways. In some of these the framework can be rearranged in approximately normal fashions as suggested by New,[2] Straith[3] and others, but in a majority of instances it is necessary to perform a more or less modified submucous resection to improve breathing, and then transplant cartilage to the dorsum to restore contour (Figs. 3 and 4).

In loss of substance from septal abscess, there must, of course, be a reconstruction, which means a transplant. The same is true in congenital failure of formation of the framework (Fig. 5).

Operative Technic.—The method which we have gradually evolved is a rather crude attempt to replace not only the dorsal edge of the septal cartilage but the alar cartilages as well. Instead of placing a long strut of cartilage along the dorsum, appropriately shaped to fill in the depression, as is the usual practice, a section of costal cartilage is removed with its perichondrium intact. This section is selected with the curve or straight line desired for the dorsal line of the nose. If a columellar support is needed, the first cut provides for a vertical post hinged to the main mass. Parallel longitudinal cuts are made on the edge opposite that selected for the dorsal ridge. These cuts go down or almost to the perichondrium and the thin wings are fractured outward so that they remain hinged by perichondrium. The median mass is thinned and shaped to a pattern previously determined from a cast of the face upon which the desired nose has been built in clay and half removed. The wings are thinned and shaped (Fig. 6).

Modeling such a transplant is a more difficult task than making a simple long strut, and it requires a wider opening to allow its introduction under the nasal skin. We make an incision usually just inside the mucocutaneous line of the alae and carry it across the columella at its junction with the nasal tip. This allows a clear view under the skin of the nose and easy introduction of the transplant. A small tunnel can be made downward for the columellar prop if it is necessary.

Such a transplant we believe is superior to the usual cantilever strut. If carried out according to indications and well conceived preoperative plans, it produces more normal appearing side walls of the nose and allows a larger airway below, because the nasal lining is not held downward by a large mass of cartilage designed merely to rest upon it in its depressed position.

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AN IMPROVEMENT IN THE APPLICATION OF BONE PLATES

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CHICAGO, ILL.

THIS is not a plea for the application of plates to fractures; simpler measures of retention should be used where they suffice. Nevertheless, there does seem to be a small percentage (about 5 per cent in my experience) where some form of internal fixation is required, and in some of these a properly applied plate offers a satisfactory means of maintaining immobilization and contact at the fracture line. But if a plate is to be employed the mechanics of its application should be as perfect as possible. Asepsis and satisfactory reduction of the fracture are taken for granted, as in all open bone surgery.

Our present concern being with the mechanics of the application of plates, six desiderata appear to be indispensable:

FIG. 1.

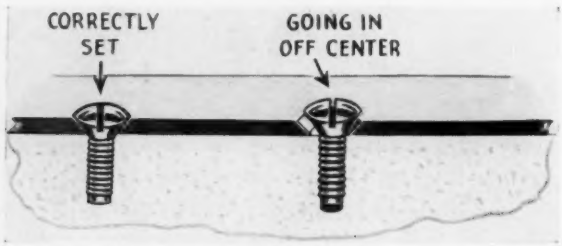

FIG. 2.

FIGS. 1 and 2.—Show a screw properly set; and one introduced off center, which causes side pressure, resulting in eventual loosening of the screw.

1. A strong plate of noncorroding metal.
2. Metal type of screws, self-tapping, same material as the plate, to prevent electrolysis.*
3. Correct size drill for the screw employed—same as the root diameter of the screw.
4. Drill-holes perfectly centered in the hole of the plate.
5. At least half of the screws long enough to engage the opposite cortex.
6. Screws snugged in place but not tightened excessively.

Submitted for publication February 14, 1938.

* Experiments are under way to prove the superior holding qualities of screws with coarser and deeper threads, designed for uniting sheet metal, bronze, monel metal, bakelite, etc., and will be reported shortly.

Considerable work has been done by Zierold, Leriche and Policard, Jones and Policard, Sherman and more recently by Venable, Stuck and Beach in improving the composition of plates and screws, but no one has offered a satisfactory means of enabling the operator to center his drill-holes correctly in the holes of the plate. The bevel of the head of the screw fits the bevel of the hole in the plate so that as the screw is tightened down it is forced into the center. The first hole makes no difference because the plate is still free to move about, but as soon as one screw is snugged in place the plate is anchored, and unless subsequent drill-holes are perfectly centered terrific side pressure is going to be exerted because the plate cannot give. This side pressure undoubtedly accounts for occasional fractures through the drill-holes, and more often for premature loosening of the screws as the bone retreats before the extreme side pressure of the screw when it is placed eccentrically (Figs. 1 and 2).

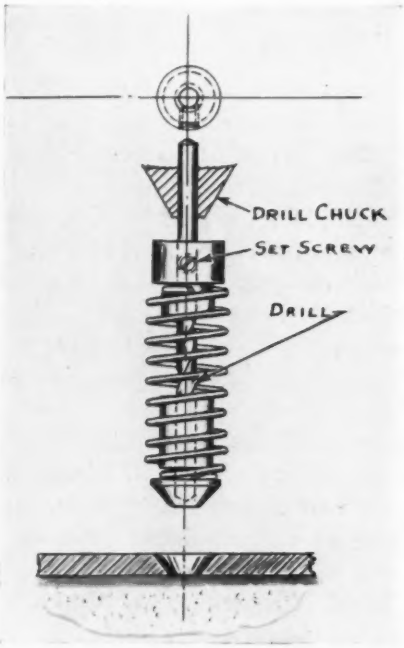

FIG. 3.—Shows a drill-centering jig, constructed to overcome the tendency to introduce the screw eccentrically.

To overcome this difficulty a small drill-centering jig has been devised, and used a sufficient number of times to justify the conclusion that it works as well practically as theoretically (Fig. 3).

The jig consists of two buttons, the upper one containing a set-screw which secures it to the drill. The lower one is beveled to fit the bevel of the hole in the plate. Between the two is a coil spring which is not attached to the buttons but encircles them loosely in a narrow groove. This spring

should be just rigid enough to withstand a sufficient pressure to keep the lower button firmly in the hole of the plate as the drill is being started, so that it is kept definitely in the center of the hole. The jig must be placed at such a height on the drill that the point does not protrude through the lower button, for if the point does protrude the jig cannot exercise its centering action. Obviously, too, a correctly sharpened drill-point will not tend to wander as will one that is ground incorrectly and asymmetrically.

Properly applied, a plate may be depended upon to give perfect immobilization at the fracture line, and external splints need be employed only for minimal protection.

FINNEY-HOWELL RESEARCH FOUNDATION, INC.

Announcement has been made by the Finney-Howell Research Foundation, Inc., that all applications for fellowships for next year must be filed in the office of the Foundation, 1211 Cathedral Street, Baltimore, Maryland, by January 1, 1939. Applications received after that date cannot be considered for 1939 awards, which will be made the first of March, 1939.

This Foundation was provided for in the will of the late Dr. George Walker of Baltimore for the support of "research work into the cause or causes and the treatment of cancer." The will directed that the surplus income from the assets of the Foundation together with the principal sum should be expended within a period of ten years to support a number of fellowships in cancer research, each with an annual stipend of two thousand dollars, "in such universities, laboratories and other institutions, wherever situated, as may be approved by the Board of Directors."

Ten such fellowships were awarded in 1938.

Fellowships carrying an annual stipend of $2000 are awarded for the period of one year, with the possibility of renewal up to three years; when deemed wise by the Board of Directors, special grants of limited sums may be made to support the work carried on under a fellowship.

Applications must be made on the blank forms which will be furnished by the Secretary or any member of the Board of Directors.

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M.D.
1833 Pine Street, Philadelphia, Pa.

Contributions in a foreign language when accepted will be translated and published in English.

Exchanges and Books for Review should be sent to James T. Pilcher, M.D., Managing Editor, 121 Gates Avenue, Brooklyn, N. Y.

Subscriptions, advertising and all business communications should be addressed

ANNALS OF SURGERY
227 South Sixth Street, Philadelphia, Pa.

INDEX TO VOLUME 108

A

ABBOTT, G. A.: Toxic Myelopathy (Spinocaine, 1001.

Abdominal Aorta and Inferior Vena Cava, Spontaneous Arteriovenous Fistula Between the, 694.

Abdominal Incision, Repair of, 741.

ABRAMS, HYMANS: The Osseous System in Hodgkin's Disease, 296.

Abscess, Brain, Treatment of, 961; and Cranial Osteomyelitis, Treatment of, 499.

Abscess, Intraperitoneal, Treatment of, Arising from Appendicitis, 833.

Actinomycosis, Treatment of, with Thymol, 468, 910.

Acute Cholecystitis, 874; in a Bacillus Typhosus Carrier, 783.

Acute Hematogenous Bursitis, 1094; Pancreatitis, Transient, 1029; Perforation of Duodenal Diverticulum, 153.

Address of President, 481.

Adenoma, Solitary Sigmoid. Malignant Transformation of a, 1107.

ADSON, ALFRED W.: Treatment of Cranial Osteomyelitis and Brain Abscess, 499.

ALLEN, FREDERICK M.: Effects of Ligations on Nerves of the Extremities, 1088.

Alteration of Tetanus Toxin within the Spinal Cord of Dogs, 941.

Anastomosis, Aseptic Intestinal, Important Steps in, 1022.

ANDERSON, DAVID P., JR.: The Problem of Wound Healing, 918.

Aneurysms, Arteriovenous, 643.

ANTON, JOSEPH I.: Madelung's Deformity, 411.

Aorta, Abdominal, and Inferior Vena Cava, Spontaneous Arteriovenous Fistula Between the, 694.

Appendicitis, Treatment of Intraperitoneal Abscess Arising from, 833.

Appendix, Intussusception of the, 1111.

Application, of Bone Plates, Improvement in, 1118; Direct, of Cod Liver Oil Upon Healing of Ulcers of the Feet in Diabetes Mellitus, Effect of, 141.

Arteries, Superior and Inferior Epigastric, Spontaneous Rupture of the, within the Rectus Abdominis Sheath, 757.

Arteriovenous Aneurysms, 643; Fistula or Fistulae, Congenital, 701; Fistula, Spontaneous, Between the Abdominal Aorta and the Inferior Vena Cava, 694.

Aseptic Intestinal Anastomosis, Important Steps in, 1022.

Aspects, Surgical, of Lesions of Meckel's Diverticulum, 221.

AUCHINCLOSS, HUGH: Obituary of Joseph A. Blake, by, 796.

Axillary Vein, Excision of, in Radical Operation for Carcinoma of the Breast, 15.

B

Bacillus Typhosus Carrier, Acute Cholecystitis in a, 783.

BANCROFT, FREDERICK W.: Treatment of Actinomycosis with Thymol, 468.

BARTLETT, ROBERT M.: Replacement of Sodium Chloride in Surgical Patients, 769.

BEAVER, JAMES L.: Acute Perforation of Duodenal Diverticulum, 153.

Beef Tendon, Chromicized, for Internal Fixation of Fractures, 1102.

BEER, EDWIN: Heminephrectomy in Disease of the Double Kidney, 705.

BENSON, CLIFFORD D.: Management of Certain Lesions of the Esophagus, 612.

BERNHARD, ADOLPH: Treatment of Postoperative Tetany with Dihydrotachysterol, 362.

BEST, CHARLES H.: Use of Heparin in Thrombosis, 163.

Bile Ducts, Traumatic Rupture of the, 237.

BINGHAM, DERMID L. C.: Replacement of Sodium Chloride in Surgical Patients, 769.

Bladder, Denervation of the, for Relief of Intractable Pain, 730; Urinary, and Extracts, Transplants, Effect of, on the Formation of Bone, 934.

BLAKE, JOSEPH AUGUSTUS: Obituary of, by Samuel W. Lambert, 791.

BLISS, ELEANOR: Toxic Manifestation of Sulfanilamide, 808.
Bone, Formation of, Effect of Urinary Bladder Transplants and Extracts on the, 934; Necrosis, Diaphyseal, Intramedullary Pressure with Reference to Massive, 127; Tendon, Fascia and Elastic Connective Tissue Transplanted into, 285; Plates, Improvement in Application of, 1118.
Book Review, The Horse and Buggy Doctor, by Arthur E. Hertzler, Reviewed by James T. Pilcher, 958.
Books Received, 960.
Brain, Carcinomatous Metastases to the, 980.
Brain Abscess, Treatment of, 961; and Cranial Osteomyelitis, Treatment of, 499.
BRANDALEONE, HAROLD: Effect of Direct Application of Cod Liver Oil Upon Healing of Ulcers of the Feet in Patients with Diabetes Mellitus, 141.
Breast, Cancer of the, Postoperative, Roentgenotherapy in, 21; Carcinoma of the, Excision of Axillary Vein in Radical Operation for, 15.
Breathing, Effect of, 95 Per Cent Oxygen upon Intraluminal Pressure Caused by Gaseous Distention of the Obstructed Small Intestine, 1012.
BREWER, GEORGE E.: Obituary of Joseph A. Blake, by, 794.
BUCHANAN, JOHN JENKINS: Obituary of, by Otto C. Gaub, 787.
BUCY, PAUL C.: Treatment of Brain Abscess, 961.
Bursitis, Acute Hematogenous, 1094.

C

CAMERON, ANGUS L.: Primary Malignancy of Jejunum and Ileum, 203.
Cancer, of the Breast, Postoperative Roentgenotherapy in, 21; Gelatinous Mammary, 321.
Carcinoma, of the Breast, Excision of Axillary Vein in Radical Operation for, 15; Primary, of the Ureter, 271; of the Rectum, Lymphatic Spread of, 621.
Carcinomatous Metastases to the Brain, 980.
Carpal Scaphoid (Navicular) Bone, Evaluation of Excision Treatment of Ununited Fracture of, 291.
Cartilage, Costal, Transplantation of, for Repairing Deficiencies of the Nasal Skeleton, 1113.
Cervical Suppuration Mediastinitis Following, 588.
Charcot's Disease of the Knee, Fusion in, 124.
Chloride, Sodium, Replacement of, in Surgical Patients, 769.
Cholecystitis, Acute, 874; in a Bacillus Typhosus Carrier, 783.
CHRISTOPHER, FREDERICK: Intussusception of the Appendix, 1111.
Chromicized Beef Tendon for Internal Fixation of Fractures, 1102.
CLARKE, WILLIAM C.: Obituary of Joseph A. Blake, by, 795.
Clinical and Experimental Shock and Its Treatment by Intravenous Injection of Preserved Plasma, 178.
Clinical Significance of Pancreatic Reflux, 243.
Cod Liver Oil, Application of, upon Healing of Ulcers of the Feet in Diabetes Mellitus, Effect of, 141.
COHEN, IRA: Epidural Spinal Infections, 992.
COLLER, FREDERICK A.: Replacement of Sodium Chloride in Surgical Patients, 769.
Colles' Fracture, Method for Reduction and Immobilization of, 156; Reversed, 472.
COLLINS, FOSTER K.: Important Steps in Aseptic Intestinal Anastomosis, 1022.
COLP, RALPH: Clinical Significance of Pancreatic Reflux, 243.
Communicating Hydrocephalus, Operative Treatment of, 194.
Congenital Arteriovenous Fistula or Fistulae, 701.
Congenital Diaphragmatic Hernia, 374.
Connective Tissue, Tendon and Fascia Transplanted into Bone, 285.
Control, Rapid, of Intracranial Pressure, 520.
COOPERMAN, MORRIS B.: Acute Hematogenous Bursitis, 1094.
COPHER, GLOVER H.: Effect of Urinary Bladder Transplants and Extracts on the Formation of Bone, 934.
Costal Cartilage, Transplantation of, for Repairing Deficiencies of the Nasal Skeleton, 1113.

Cranial Osteomyelitis and Brain Abscess, Treatment of, 499.
CROHN, BURRILL B.: Perianal Fistula as a Complication of Regional Ileitis, 867.
CURTIS, GEORGE M.: Iodine Metabolism in Exophthalmic Goiter, 574.
CUTLER, CONDICT W., JR.: Changing Methods in Surgical Treatment of Peptic Ulcer, 68.
Cysts, Epidermoid, of the Spleen, 877; Sublingual Epidermoid, 305.

D

DANDY, WALTER E.: Operative Treatment of Communicating Hydrocephalus, 194.
DAVID, VERNON C.: Lymphatic Spread of Carcinoma of the Rectum, 621.
DAVIDSON, ARTHUR J.: Evaluation of Excision Treatment of Ununited Fracture of Carpal Scaphoid (Navicular) Bone, 291.
DAVIS, LOYAL: Obituary of Allen B. Kanavel, by, 788.
Deficiencies of the Nasal Skeleton, Repair of, by Transplantation of Costal Cartilage, 1113.
Deformity, Madelung's, 411.
Denervation of the Bladder for Relief of Intractable Pain, 730.
Diabetes Mellitus, Effect of Direct Application of Cod Liver Oil Upon Healing of Ulcers of the Feet in, 141.
Diabetes and Surgery, 1052.
Diagnosis, Differential, of Hyperparathyroidism, 347.
Diaphragmatic Hernia, Congenital, 374.
Diaphyseal Bone Necrosis, Intramedullary Pressure with Reference to Massive, 127.
Differential Diagnosis of Hyperparathyroidism, 347.
Dihydrotachysterol, Postoperative Tetany with, Treatment of, 362.
Direct Application of Cod Liver Oil Upon Healing of Ulcers of the Feet in Diabetes Mellitus, Effect of, 141.
Direct Inguinal Hernia, 389.
Disease, Charcot's, of the Knee, Fusion in, 124; of the Double Kidney, Heminephrectomy in, 705; Hodgkin's, The Osseous System in, 296.
Distention, Gaseous, of the Obstructed Small Intestine, Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Caused by, 1012.
Diverticulum, Duodenal, Acute Perforation of, 153; Meckel's, Surgical Aspects of Lesions of, 221.
DIXON, CLAUDE F.: Regional Enteritis, 857.
Dogs, Spinal Cord of, Alteration of Tetanus Toxin within the, 941.
DONOVAN, EDWARD J.: Congenital Diaphragmatic Hernia, 374.
DOUBILET, HENRY: Clinical Significance of Pancreatic Reflux, 243.
Double Kidney, Heminephrectomy in Disease of the, 705.
DRAGSTEDT, LESTER R.: Renal Hypertension, 263.
DRUCKERMAN, LEONARD J.: Malignant Transformation of a Solitary Sigmoid Adenoma, 1107.
Duodenal Diverticulum, Acute Perforation of, 153.

E

Education, Medical, Licensure and Hospitals, Need of National Council on, 480.
Effect, of Breathing 95 Per cent Oxygen Upon Intraluminal Pressure Caused by Gaseous Distention of the Obstructed Small Intestine, 1012; of Direct Application of Cod Liver Oil Upon Healing of Ulcers of the Feet in Diabetes Mellitus, 141; of Sulfanilamide upon Human, Virulent Hemolytic Streptococci, 813; of Urinary Bladder Transplants and Extracts on the Formation of Bone, 934.
Effects of Ligations on Nerves of the Extremities, 1088.
EGGERS, CARL: Gastro-enterostomy, 84.
Elastic Connective Tissue Transplanted into Bone, Tendon, Fascia and, 285.
ELIASON, ELDRIDGE L.: Memoir of Edward Martin, by, 480.
ELLIOTT, ROBERT H. E., JR.: Repair of Abdominal Incisions, 741.
ELTING, ARTHUR W.: Relation of Surgeon and Hospital, 481.
Embryoma of the Kidney (Wilms' Tumor), 885.
Enteritis, Regional, 857.
Epidermoid Cysts, of the Spleen, 877; Sublingual, 305.
Epidural Spinal Infections, 992.

Epigastric Arteries, Superior and Inferior, Spontaneous Rupture of the, within the Rectus Abdominis Sheath, 757.
Erratum, 320.
Esophagus, Management of Certain Lesions of the, 612.
Evaluation of Excision in Treatment of Ununited Fracture of Carpal Scaphoid (Navicular) Bone, 291.
Excision, of Axillary Vein in Radical Operation for Carcinoma of the Breast, 15.
Excision, Evaluation of, in Treatment of Ununited Fracture of Carpal Scaphoid (Navicular) Bone, 291.
Exophthalmic Goiter, Iodine Metabolism in, 574.
Exophthalmos, Progressive, Associated with Disorders of the Thyroid Gland, 529.
Experimental and Clinical Shock and Its Treatment by Intravenous Injection of Preserved Plasma, 178.
Extracts and Urinary Bladder Transplants, Effect of, on the Formation of Bone, 934.
Extremities, Nerves of the, Effects of Ligations on, 1088.

F

FAHEY, JOHN: Tendon, Fascia and Elastic Connective Tissue Transplanted into Bone, 285.
Fascia, Tendon and Elastic Connective Tissue Transplanted into Bone, 285.
Fecal Fistula, Spontaneous, Strangulated Littre's Femoral Hernia with, 1076.
Feet, Ulcers of the, Effect of Direct Application of Cod Liver Oil Upon Healing of, in Diabetes Mellitus, 141.
Femoral Hernia, Strangulated Littre's, with Spontaneous Fecal Fistula, 1076.
Femur, Neck of the, Intracapsular Fractures of the, 440.
FINE, JACOB: Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Occasioned by Gaseous Distention of the Obstructed Small Intestine, 1012.
FINNEY-HOWELL: Research Foundation, Inc., 1120.
FIROR, WARFIELD M.: Apparent Alteration of Tetanus Toxin within the Spinal Cord of Dogs, 941.
Fistula, Congenital Arteriovenous, 701; Spontaneous Arteriovenous, Between the Abdominal Aorta and the Inferior Vena Cava, 694; Spontaneous Fecal, Strangulated Littre's Femoral Hernia with, 1076.
Fistulae, Perianal, as a Complication of Regional Ileitis, 867.
Fixation of Fractures, Internal, Chromicized Beef Tendon for, 1102.
Fracture of Carpal Scaphoid (Navicular) Bone, Evaluation of Excision Treatment of Ununited, 291; Colles', Method for Reduction and Immobilization of, 156; Reversed Colles', 472.
Fractures, Internal Fixation of, Chromicized Beef Tendon for, 1102; Intracapsular, of the Neck of the Femur, 440.
FRANK, ALBERT A.: Epidermoid Cysts of the Spleen, 877.
FUGE, WILFRED W.: Insensible Loss in Surgical Patients, 1.
Fusion in Charcot's Disease of the Knee, 124.

G

GARLOCK, JOHN H.: Differential Diagnosis of Hyperparathyroidism, 347.
GARRISON, MONROE: Tendon, Fascia and Elastic Connective Tissue Transplanted into Bone, 285.
Gaseous Distention of the Obstructed Small Intestine. Effect of Breathing 95 Per Cent Oxygen Upon the Intraluminal Pressure Caused by, 1012.
Gastro-enterostomy, 84.
GAUB, OTTO C.: Obituary of John Jenkins Buchanan by, 787.
GEER, WILLIAM A.: Renal Hypertension, 263.
Gelatinous Mammary Cancer, 321.
GERMAN, WILLIAM J.: Carcinomatous Metastases to the Brain, 980.
GESCHICKTER, CHARLES F.: Gelatinous Mammary Cancer, 321.
GILCHRIST, RICHARD K.: Lymphatic Spread of Carcinoma of the Rectum, 621.
Gland, Thyroid, Progressive Exophthalmus Associated with Disorders of the, 529.
Goiter, Diffuse Toxic, Amount of Thyroid Tissue to Be Left in Operations for, 563; Exophthalmic, Iodine Metabolism in, 574.
GRAHAM, HENRY F.: Acute Cholecystitis, 874; Efficient Method for Reduction and Immobilization of Colles' Fracture, 156.
GRAY, S. H.: Transient Acute Pancreatitis, 1029.

GREENOUGH, ROBERT B.: Obituary of, by Channing C. Simmons, 798.
GROSSMAN, ABRAHAM: Postoperative Jejunal Ulcer, 105.

H

HAND, FRED E.: Improvement in Application of Bone Plates, 1118.
Healing, The Problem of Wound, 918.
HEIFETZ, CARL J.: Transient Acute Pancreatitis, 1029.
Hematogenous Bursitis, Acute, 1094.
Hematogenous Nephritis, Treatment of, with Sulfanilamide, 828.
Heminephrectomy in Disease of the Double Kidney, 705.
Hemolytic Streptococci, Human, Virulent, Effect of Sulfanilamide upon, 813.
Heparin in Thrombosis, Use of, 163.
Hernia, Congenital Diaphragmatic, 374; Direct Inguinal, 289; Strangulated Littre's Femoral, with Spontaneous Fecal Fistula, 1076.
HERTZLER, ARTHUR E.: The Horse and Buggy Doctor, 958.
HIGGINS, CHARLES C.: Primary Carcinoma of the Ureter, 271.
Hodgkin's Disease, The Osseous System in, 296.
HOEFLE, MILTON E.: Acute Cholecystitis, 874.
HOGG, BRUCE M.: Insensible Loss in Surgical Patients, 1.
HOOVER, WALTER B.: Injuries to the Recurrent Laryngeal Nerve in Thyroid Operations, 545.
HORWITZ, M. THOMAS: Evaluation of Excision in Treatment of Ununited Fracture of Carpal Ecaphoid (Navicular) Bone, 291.
HUGHES, BOLAND: Therapeutic Management of Urinary Infections, 903.
Human, Virulent Hemolytic Streptococci, Effect of Sulfanilamide upon, 813.
Hydrocephalus, Communicating, Operative Treatment of, 194.
Hyperparathyroidism, Differential Diagnosis of, 347.
Hypertension, Renal, 263.

I

Ileitis, Regional, Perianal Fistulae as a Complication of, 867.
Ileum and Jejunum, Primary Malignancy of, 203.
Immobilization and Reduction of Colles' Fracture, Method for, 156.
Important Steps in Aseptic Intestinal Anastomosis, 1022.
Improvement in Application of Bone Plates, 1118.
Incision, Modification of, for Thoracoplasty, 154.
Incisions, Repair of Abdominal, 741.
Infections, Epidural Spinal, 992; Surgical, Sulfanilamide and Its Application to, 801; Urinary, Therapeutic Management of, 903.
Inferior and Superior Epigastric Arteries, Spontaneous Rupture of the, within the Rectus Abdominis Sheath, 757.
Inferior Vena Cava and the Abdominal Aorta, Spontaneous Arteriovenous Fistula Between the, 694.
Inguinal Hernia, Direct, 389.
Injection, Intravenous, of Preserved Plasma, Experimental and Clinical Shock and Its Treatment by, 178.
Injuries to the Recurrent Laryngeal Nerve in Thyroid Operations, 545.
Insensible Loss in Surgical Patients, 1.
Internal Fixation of Fractures, Chromicized Beef Tendon for, 1102.
Intestinal Anastomosis, Aseptic, Important Steps in, 1022.
Intestine, Small, Obstructed, Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Caused by Gaseous Distention of the, 1012.
Intracapsular Fractures of the Neck of the Femur, 440.
Intracranial Pressure, Rapid Control of, 520.
Intraluminal Pressure, Effect of Breathing 95 Per Cent Oxygen upon, Caused by Gaseous Distention of the Obstructed Small Intestine, 1012.
Intramedullary Pressure with Reference to Massive Diaphyseal Bone Necrosis, 127.
Intraperitoneal Abscess, Treatment of, Arising from Appendicitis, 833.
Intravenous Injection of Preserved Plasma, Experimental and Clinical Shock and Its Treatment by, 178.
Intussusception of the Appendix, 1111.

Iodine Metabolism in Exophthalmic Goiter, 574.

J

Jejunal Ulcer, Postoperative, 105.
Jejunum and Ileum, Primary Malignancy of, 203.
JOHN, HENRY J.: Surgery and Diabetes, 1052.
JOYCE, THOMAS M.: Thymol Therapy in Actinomycosis, 910.

K

KANAVEL, ALLEN BUCKNER: Obituary of, by Loyal Davis, 788; by Dallas B. Phemister, 161.
KELMAN, HAROLD: Toxic Myelopathy (Spinocaine), 1001.
KERNWEIN, GRAHAM: Tendon, Fascia and Elastic Connective Tissue Transplanted into Bone, 285.
Kidney, Double, Heminephrectomy in Disease of the, 705; Embryoma of the (Wilms' Tumor), 885.
Knee, Fusion in Charcot's Disease of the, 124.

L

LADD, WILLIAM E.: Embryoma of the Kidney (Wilms' Tumor), 885.
LAHEY, FRANK H.: Injuries to the Recurrent Laryngeal Nerve in Thyroid Operations, 545.
LAMBERT, SAMUEL: Obituary of Joseph A. Blake, by, 791.
LAMONT, AUSTIN: Apparent Alteration of Tetanus Toxin within the Spinal Cord of Dogs, 941.
LARSEN, RALPH M.: Intramedullary Pressure with Reference to Massive Diaphyseal Bone Necrosis, 127.
Laryngeal Nerve, Injuries to Recurrent, in Thyroid Operations, 545.
LEHMAN, EDWIN P.: Spontaneous Arteriovenous Fistula Between the Abdominal Aorta and the Inferior Vena Cava, 694; Treatment of Intraperitoneal Abscess Arising from Appendicitis, 833.
Lesions, Certain, of the Esophagus, Management of, 612; of Meckel's Diverticulum, Surgical Aspects of, 221.
LEWIS, KENNETH M.: Traumatic Rupture of the Bile Ducts, 237.
Ligations, Effects of, on Nerves of the Extremities, 1088.
LILIENTHAL, HOWARD: Modification of Incision for Thoracoplasty, 154.
LISANSKY, EPHRAIM T.: Congenital Arteriovenous Fistula, 701.
Littre's Femoral Hernia, Strangulated, with Spontaneous Fecal Fistula, 1076.
LOCKWOOD, JOHN S.: Sulfanilamide and Its Application to Surgical Infections, 801
LONG, PERRIN H.: Toxic Manifestation of Sulfanilamide, 808.
Loss, Insensible, in Surgical Patients, 1.
Lymphatic Spread of Carcinoma of the Rectum, 621.
LYON, WILL F.: Improvement in Application of Bone Plates, 1118.
LYONS, CHAMP: Effect of Sulfanilamide upon Human, Virulent Hemolytic Streptococci, 813.

M

MACGUIRE, CONSTANTINE J., JR.: Acute Cholecystitis in a Bacillus Typhosus Carrier, 783.
MADDOCK, WALTER G.: Replacement of Sodium Chloride in Surgical Patients, 769.
Madelung's Deformity, 411.
MAHONEY, EARLE B.: Experimental and Clinical Shock and Its Treatment by Intravenous Injection of Preserved Plasma, 178.
Malignancy, Primary, of Jejunum and Ileum, 203.
Malignant Transformation of a Solitary Sigmoid Adenoma, 1107.
Mammary Cancer, Gelatinous, 321.
Management, of Certain Lesions of the Esophagus, 612; Therapeutic, of Urinary Infections, 903.
MANGIARACINE, ANITA: Effect of Sulfanilamide upon Human, Virulent Hemolytic Streptococci, 813.
MANHEIM, SYLVAN D.: Malignant Transformation of a Solitary Sigmoid Adenoma, 1107.
Manifestation, Toxic, of Sulfanilamide, 808.
MARTIN, EDWARD: Memoir by Eldridge L. Eliason, 480.
MARTIN, WALTON: Obituary of Joseph A. Blake, by, 794.
MCCARROLL, H. R.: Regeneration of Sensation in Transplanted Skin, 309.
MCENERY, EUGENE T.: Epidermoid Cysts of the Spleen, 877.

McGuire, Johnson: Arteriovenous Aneurysms, 643.
McQuillan, Arthur S.: Parathyroid Tumor, 464.
Meckel's Diverticulum, Surgical Aspects of Lesions of, 221.
Mediastinitis Following Cervical Suppuration, 588.
Medical Education, Licensure and Hospitals, Need of National Council on, 489.
Mencher, William H.: Heminephrectomy in Disease of the Double Kidney, 705.
Metabolism, Iodine, in Exophthalmic Goiter, 574.
Metastases, Carcinomatous, to the Brain, 980.
Method for Reduction and Immobilization of Colles' Fracture, 156.
Modification of Incision for Thoracoplasty, 154.
Montgomery, Albert H.: Epidermoid Cysts of the Spleen, 877.
Murray, Gordon D. W.: Use of Heparin in Thrombosis, 163.
Myelopathy, Toxic (Spinocaine), 1001.

N

Naffziger, Howard C.: Progressive Exophthalmos Associated with Disorders of the Thyroid Gland, 529.
Nasal Skeleton, Repair of, by Transplantation of Costal Cartilage, 1113.
Navicular Bone (Carpal Scaphoid), Evaluation of Excision Treatment of Ununited Fracture of, 291.
Neck of the Femur, Intracapsular Fractures of the, 440.
Necrosis, Massive Diaphyseal Bone, Intramedullary Pressure with Reference to, 127.
Need of National Council on Medical Education, Licensure and Hospitals, 489.
Nephritis, Hematogenous, Treatment of, with Sulfanilamide, 828.
Nerve, Injuries to the Recurrent Laryngeal, in Thyroid Operations, 545.
Nerves of the Extremities, Effects of Ligations on, 1088.
Neuhof, Harold: Excision of Axillary Vein in Radical Operation for Carcinoma of the Breast, 15.
Ninety-five Per cent Oxygen, Effect of Breathing, upon Intraluminal Pressure Caused by Gaseous Distention of the Obstructed Small Intestine, 1012.

O

Obstructed Small Intestine, Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Caused by Gaseous Distention of the, 1012.
Operation, Radical, for Carcinoma of the Breast, Excision of Axillary Vein in, 15.
Operative Treatment of Communicating Hydrocephalus, 194.
Osseous System in Hodgkin's Disease, 296.
Osteomyelitis and Brain Abscess, Treatment of Cranial, 499.
Oxygen, 95 Per Cent, Effect of Breathing of, upon Intraluminal Pressure Caused by Gaseous Distention of the Obstructed Small Intestine, 1012

P

Pain, Relief of Intractable, Denervation of the Bladder for, 730.
Pancreatic Reflux, Clinical Significance of, 243.
Pancreatitis, Transient Acute, 1029.
Parathyroid Tumor, 464.
Parker, William H.: Treatment of Intraperitoneal Abscess Arising from Appendicitis, 833.
Patients, Insensible Loss in Surgical, 1; Surgical, Replacement of Sodium Chloride in, 769.
Payne, Robert L.: Spontaneous Rupture of the Superior and Inferior Epigastric Arteries within the Rectus Abdominis Sheath, 757.
Pearse, Herman E., Jr.: Mediastinitis Following Cervical Suppuration, 588.
Pedersen, Svend: Replacement of Sodium Chloride in Surgical Patients, 769.
Penberthy, Grover C.: Management of Certain Lesions of the Esophagus, 612.
Penner, Abraham: Perianal Fistulae as a Complication of Regional Ileitis, 867.
Peptic Ulcer, 32; Changing Methods in Surgical Treatment of, 68.
Perforation, Acute, of Duodenal Diverticulum, 153.
Perianal Fistulae as a Complication of Regional Ileitis, 867.
Perineal Testis, 1083.
Phemister, Dallas B.: Memoir of Allen B. Kanavel, by, 161.

PICKHARDT, OTTO C.: Treatment of Postoperative Tetany with Dihydrotachysterol, 362.
PILCHER, JAMES T.: Review of Arthur E. Hertzler's The Horse and Buggy Doctor, by, 958.
Plasma, Preserved, Experimental and Clinical Shock and Its Treatment by Intravenous Injection of, 178.
Postoperative Jejunal Ulcer, 105; Roentgenotherapy in Cancer of the Breast, 21; Tetany with Dihydrotachysterol, The Treatment of, 362.
PRESENT, ARTHUR J.: Peptic Ulcer, 32.
Preserved Plasma, Experimental and Clinical Shock and Its Treatment by Intravenous Injection of, 178.
Presidential Address, 481.
Pressure, Intracranial, Rapid Control of, 520; Intraluminal, Effect of Breathing 95 Per Cent Oxygen upon, Caused by Gaseous Distention of the Obstructed Small Intestine, 1012; Intramedullary, with Reference to Massive Diaphyseal Bone Necrosis, 127.
Primary Carcinoma of the Ureter, 271; Malignancy of Jejunum and Ileum, 203.
Problem of Wound Healing, 918.
PROBSTEIN, J. G.: Transient Acute Pancreatitis, 1029.
Progressive Exophthalmos Associated with Disorders of the Thyroid Gland, 529.
PUPPEL, ITALO D.: Iodine Metabolism in Exophthalmic Goiter, 574.

R

RANDALL, ALEXANDER: Therapeutic Management of Urinary Infections, 903.
Rapid Control of Intracranial Pressure, 520.
RAPPLEYE, WILLARD C.: Need of National Council on Medical Education, Licensure and Hospitals, 489.
REA, CHARLES E.: Perineal Testis, 1083.
Rectum, Carcinoma of the, Lymphatic Spread of, 621.
Recurrent Laryngeal Nerve, Injuries to, in Thyroid Operations, 545.
Reduction and Immobilization of Colles' Fracture, Method for, 156.
Reflux, Pancreatic, Clinical Significance of, 243.
Regeneration of Sensation in Transplanted Skin, 309.
Regional Enteritis, 857; Ileitis, Perianal Fistulae as a Complication of, 867.
REID, MONT R.: Arteriovenous Aneurysms, 643.
REITZ, GEORGE B.: Madelung's Deformity, 411.
Relation of Surgeon and Hospital, 481.
Relief of Pain, Denervation of the Bladder for, 730.
Renal Hypertension, 263.
Repair of Abdominal Incisions, 741.
Replacement of Sodium Chloride in Surgical Patients, 769.
Research Foundation, Inc., Finney-Howell, 1120.
Reversed Colles' Fracture, 472.
ROBINS, CHARLES R.: Direct Inguinal Hernia, 389.
Roentgenotherapy, Postoperative, in Cancer of the Breast, 21.
ROSENFELD, LOUIS: Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Occasioned by Gaseous Distention of the Obstructed Small Intestine, 1012.
Rupture, Spontaneous, of Superior and Inferior Epigastric Arteries within the Rectus Abdominis Sheath, 757; Traumatic, of the Bile Ducts, 237.
RUSSELL, JAMES I.: Obituary of Joseph A. Blake, by, 795.

S

Scaphoid, Carpal (Navicular) Bone, Evaluation of Excision Treatment of Ununited Fracture of, 291.
SCHMIDT, ERWIN R.: Rapid Control of Intracranial Pressure, 520.
SCHROEDER, CARLISLE F.: Denervation of the Bladder for Relief of Intractable Pain, 730.
SCOTT, W. J. MERLE: Denervation of the Bladder for Relief of Intractable Pain, 730.
Sensation, Regeneration of, in Transplanted Skin, 309.
Shock, Experimental and Clinical, and Its Treatment by Intravenous Injection of Preserved Plasma, 178.
SHORE, BENJAMIN R.: Sublingual Epidermoid Cysts, 305.
SIEGERT, R. B.: Surgical Aspects of Lesions of Meckel's Diverticulum, 221.

Sigmoid Adenoma, Solitary, Malignant Transformation of a, 1107.
Significance, Clinical, of Pancreatic Reflux, 243.
SIMMONS, CHANNING C.: Obituary of Robert B. Greenough, by, 798.
Skeleton, Nasal, Transplantation of Costal Cartilage for Repairing Deficiencies of the, 1113.
Skin, Transplanted, Regeneration of Sensation in, 309.
Small Intestine, Obstructed, Effect of Breathing 95 Per Cent Oxygen upon the Intraluminal Pressure Caused by Gaseous Distention of the, 1012.
SMITH, MORRIS K.: Amount of Thyroid Tisssue to Be Left in Operations for Diffuse Toxic Goiter, 563.
SNODGRASS, LEEMAN E.: Reversed Colles' Fracture, 472.
Sodium Chloride, Replacement of, in Surgical Patients, 769.
Solitary Sigmoid Adenoma, Malignant Transformation of a, 1107.
SOTO-HALL, RALPH: Fusion in Charcot's Disease of the Knee, 124.
SPIEGEL, MILTON B.: Madelung's Deformity, 411.
Spinal Cord of Dogs, Alteration of Tetanus Toxin within the, 941.
Spinal, Epidural, Infections, 992.
Spinocaine (Toxic Myelopathy), 1001.
Spleen, Epidermoid Cysts of the, 877.
Spontaneous Arteriovenous Fistula Between the Abdominal Aorta and the Inferior Vena Cava, 694; Fecal Fistula, Strangulated Littre's Femoral Hernia with, 1076; Rupture of Superior and Inferior Epigastric Arteries within the Rectus Abdominis Sheath, 757.
Spread, Lymphatic, of Carcinoma of the Rectum, 621.
STANLEY-BROWN, M.: Treatment of Actinomycosis with Thymol, 468.
Steps, Important, in Aseptic Intestinal Anastomosis, 1022.
Strangulated Littre's Femoral Hernia with Spontaneous Fecal Fistula, 1076.
Streptococci, Hemolytic, Human, Virulent, Effect of Sulfanilamide upon, 813.
STRICKLER, FRANK P.: Chromicized Beef Tendon for Internal Fixation of Fractures, 1102.
Sublingual Epidermoid Cysts, 305.
Sulfanilamide, Effect of, upon Human, Virulent Hemolytic Streptococci, 813; and Its Application to Surgical Infections, 801; Toxic Manifestation of, 808; Treatment of Hematogenous Nephritis with, 828.
Superior and Inferior Epigastric Arteries, Spontaneous Rupture of the, within the Rectus Abdominis Sheath, 757.
Suppuration, Cervical, Mediastinitis Following, 588.
Surgery and Diabetes, 1052.
Surgical Aspects of Lesions of Meckel's Diverticulum, 221; Infections, Sulfanilamide and Its Application to, 801; Patients, Insensible Loss in, 1; Patients, Replacement of Sodium Chloride in, 769; Treatment of Peptic Ulcer, Changing Methods in the, 68.
System, The Osseous, in Hodgkin's Disease, 296.

T

Tendon, Chromicized Beef, for Internal Fixation of Fractures, 1102; Fascia and Elastic Connective Tissue Transplanted into Bone, 285.
Testis, Perineal, 1083.
Tetanus Toxin, Alteration of, within the Spinal Cord of Dogs, 941.
Tetany, Postoperative, with Dihydrotachysterol, The Treatment of, 362.
Therapeutic Management of Urinary Infections, 903.
Thoracoplasty, Modification of Incision for, 154.
Thrombosis, Use of Heparin in, 163.
Thymol, Treatment of Actinomycosis with, 468, 910.
Thyroid Gland, Progressive Exophthalmus Associated with Disorders of the, 529; Operations, Injuries to the Recurrent Laryngeal Nerve in, 545; Tissue, Amount of, to Be Left in Operations for Diffuse Toxic Goiter, 563.
Tissue, Thyroid, Amount of, to Be Left in Operations for Diffuse Toxic Goiter, 563.
Toxic Manifestation of Sulfanilamide, 808; Myelopathy (Spinocaine), 1001.
Toxin, Tetanus, Alteration of, within the Spinal Cord of Dogs, 941.
Transformation, Malignant, of a Solitary Sigmoid Adenoma, 1107.

Transient Acute Pancreatitis, 1029.
Transplantation of Costal Cartilage for Repairing Deficiencies of the Nasal Skeleton, 1113.
Transplanted Skin, Regeneration of Sensation in, 309.
Traumatic Rupture of the Bile Ducts, 237.
Treatment, of Actinomycosis with Thymol, 468; of Brain Abscess, 961; of Cranial Osteomyelitis and Brain Abscess, 499; of Hematogenous Nephritis with Sulfanilamide, 828; of Intraperitoneal Abscess Arising from Appendicitis, 833; Operative, of Communicating Hydrocephalus, 194; Surgical, of Peptic Ulcer, Changing Methods in the, 68; of Ununited Fracture of Carpal Scaphoid (Navicular) Bone, Evaluation of Excision, 291.
Tumor, Parathyroid, 464; Wilms', Embryoma of the Kidney, 885.
Typhosus Carrier, Bacillus, Acute Cholecystitis in a, 783.

U

Ulcer, Jejunal, Postoperative, 105; Peptic, 32; Peptic, Changing Methods in Surgical Treatment of, 68.
Ulcers of the Feet in Diabetes Mellitus, Effect of Direct Application of Cod Liver Oil Upon Healing of, 141.
Ununited Fracture of Carpal Scaphoid (Navicular) Bone, Evaluation of Excision Treatment of, 291.
Ureter, Primary Carcinoma of the, 271.
Urinary Bladder Transplants, Effect of, and Extracts on the Formation of Bone, 934; Infections, Therapeutic Management of, 903.
Use of Heparin in Thrombosis, 163.

V

Vein, Excision of Axillary, in Radical Operation for Carcinoma of the Breast, 15.
Vena Cava, Inferior, and Abdominal Aorta, Spontaneous Arteriovenous Fistula Between the, 694.
VEST, SAMUEL A.: Treatment of Hematogenous Nephritis with Sulfanilamide, 828.

W

WADE, PRESTON A.: Intracapsular Fractures of the Neck of the Femur, 440.
WEINSTEIN, BERNARD M.: Strangulated Littre's Femoral Hernia with Spontaneous Fecal Fistula, 1076.
WHIPPLE, ALLEN O.: Obituary of Joseph A. Blake, by, 795; Repair of Abdominal Incisions, 741.
WHITE, WILLIAM C.: Postoperative Roentgenotherapy in Cancer of the Breast, 21.
Wilms' Tumor, Embryoma of the Kidney, 885.
WISE, WALTER D.: Congenital Arteriovenous Fistula, 701.
WOMACK, NATHAN A.: Surgical Aspects of Lesions of Meckel's Diverticulum, 221.
Wound Healing, The Problem of, 918.

Y

YOUNG, FORREST: A Principle to Be Considered in Transplanting Costal Cartilage for Repairing Deficiencies of the Nasal Skeleton, 1113.
YOUNG, HUGH H.: Treatment of Hematogenous Nephritis with Sulfanilamide, 828.